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On Our Cover

Glimpses of 15th Lubricating Grease Conference held at Kovalam during February 3-5, 2013

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Performance of Grease in Roll Table Bearing in Hot Strip Mill

D. Keshari
INDIAN OIL CORPORATION LTD(MD), RANCHI

Introduction

Steel Plants encounter one of the most severe application regimes as far as lubrication is concerned. In Steel Mills, the bearings of the Roll Table in front of the Furnace area are subjected to Severe Service Conditions. In order to have satisfactory performance of the bearings, the greases should sustain high temperature.

High performance specialty greases are designed to extend the service life of the bearings in high temperature, shock load and high water jet cooling applications. These greases match the rugged service requirements of rolling mills. Load carrying and anti wear capabilities of these greases along with high performance is the result of chemical additives working synergistically with solid lubricants. These additives are dispersed uniformly throughout the greases attributing superior load carrying/ anti wear characteristics and excellent water resistance to cold and hot water.

After completion of successful trial the products are to be accorded "proven" status and can be used on a regular basis. The present paper highlights results of the trail of the Candidate Grease.

A Water Resistant, High Load bearing premium quality Candidate Grease was developed with required performance criteria. This is specially formulated to meet the demand of severe water wash-out and AW grease for boundary lubrication. This grease is recommended for both plain and anti-friction bearings for wide variety of applications such as automotive and industrial applications. It is preferred for Steel Mill Lubrication under high load and high water wash-out conditions.

The plant was facing severe bearing failure problem and grease burnout in the application area. This Candidate Grease was offered for trial in the Roll Table Bearing near Re-heating Furnace Area in Hot Strip Mill.

Properties of the Grease

The Candidate Grease is specially developed to meet the severe application requirement of high temperature and shock load sustainability. The properties of the grease is tabulated in Annexure-I. Some of the expected performance are listed below:

- Has excellent resistance to Oxidation.
- High Temperature and Shock Load sustainability.

- Ensures minimum softening and loss of structure even when subjected to substantial shear.
- Has excellent resistance to Water Wash-out.
- Prevents spot welding and seizure of moving parts often caused by shock loading.

HOT STRIP MILL

Slabs from CCS and Slabbing Mill are processed in the state-of-the-art Hot Strip Mill. The fully automatic Hot Strip Mill with an annual capacity of 3.995 million tonnes has a wide range of products - thickness varying from 1.2 mm to 20 mm and width from 750 mm to 1850 mm.

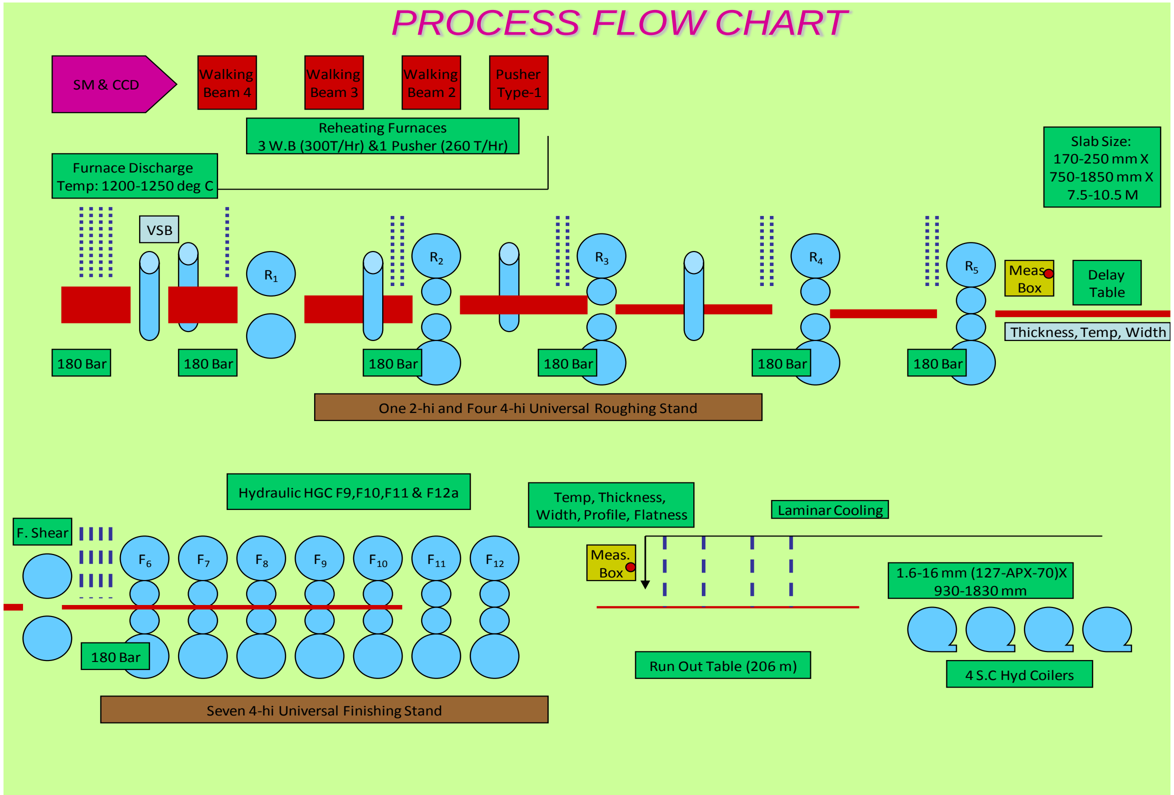
MAIN UNITS OF HOT STRIP MILL

Unit	No	Capacity
	3 Nos (Walking Beam Type)	300 T/Hr
Furnaces	1 Nos (Pusher Type)	260 T/Hr
Roughing Mill	5 Nos (R1 to R5)	
Finsihing Mill Stand	7 Nos (F6 to F12)	
Coilers	4 Nos	

Technical Parameters of the Hot Strip Mill

Slab Thickness	:	180 - 250 mm for strip production
Roughing Mill	:	One (1) 2-Hi and Four (4) 4- Hi Mill Stands
Finishing Mill	:	Seven (7) 4 - Hi Mill stands
Strip thickness		1.5 mm - 12.7 mm (API grades upto X70)
	:	16.0 mm (Carbon Steel)
Strip width	:	930 mm - 1830 mm
Coil I.D.	:	850 mm
Coil O.D	:	1400 - 2300 mm.
Coil weight	:	32000 Kg. (max.)
Specific coil weight	:	20 kg/mm/coil width (max.)
Coiler type	:	Four (4) Coilers with step control

HOT STRIP MILL



Process Flow Chart- Hot Strip Mill

APPLICATION AREA OF THE CANDIDATE GREASE

The Slabs from Slabbing Mill and Continuous Casting Shop are fed into the Rehearing Furnace from one end and are discharged from the other end. The Slabs are heated in the Reheating Furnaces for about 8-10 hrs during which the slabs are raised to a temperature of 1100 ^{0}C. The Furnaces Discharge Doors remain closed during the heating process. The Doors open at the time of discharge of the Hot Slab and closes soon after. It normally takes one minute for each slab discharge. The process repeats itself after every 4 minutes for each furnace. Hence, on an average, there is a discharge of one slab per minute considering all 4 furnaces. The hot slabs are then made to travel on Roll Table through the Roughing Stands & Finishing Stands where the slabs are converted to Hot Strips and then to the Coiler for Coiling of the Hot Strip. The Roll Table has several rollers connected to the motors for smoother travel of the hot metal. The two end bearings of each such Roller are lubricated by Grease through Centralized Greasing System.

The bearings of the rollers placed in front of the Furnaces get exposed to very high temperature when the Furnace Discharge Doors are open. Owing to the criticality of the application, Greasing is done through Centralized Greasing System twice a day and manual greasing is done through grease gun, if required.

The bearing Housings are Water Cooled through circulating water jacket to keep the inner race of the bearing within the controlled temperature (55-60 deg C).

The specifications of the Bearings are as under:

Bearing No	: 2097144 (Russian make)
Structure	: Self-Aligning
Type	: Double row taper Roller bearing.
Outside Diameter	:340 mm

The bearings are lubricated with the grease of other make.

SPECIFICATIONS OF CONVENTIONAL GREASE

The Conventional Grease which was in use had following specifications:

Property	**Test method**	Result
Appearance	Visual	Homogeneous
Colour	Visual	Dark brown
Penetration @ 25° C, Worked	D-217	305
Dropping point° C	D-566	245
Weld load, kg	IP-239	250
Wear scar dia, mm	D-2266	0.65
Base oil viscosity, cSt At 40 °C At 100 °C VI	D 445	 122.4 11.67 79

ABOUT THE PROBLEM

Due to production pressure, the plant was not able to take necessary preventive maintenance of the Furnaces. As such, the furnace doors were not getting closed properly, resulting in tremendous Heat Radiation from the Furnaces. The furnace side bearing housings of the Roll Table got exposed to 370 deg C when the Furnace Doors were closed and shot up to 450 deg C when Furnace Discharge Doors were opened.

Heat Radiation with Furnace Door Close

Heat Radiation with Furnace Door Open

In order to keep the bearings lubricated in the high temperature exposure, the customer increased the manual greasing frequency in the Bearings near the Furnace Areas with the Conventional Grease from once a day to once a shift in addition to the Centralized greasing done twice a day. However, due to high temperature exposure, the grease used to get melt and drop down resulting in frequent Grease dry problems resulting in bearing failures.

Even after frequent re-greasing, there were on an average one bearing failure per Roll per month.

As the bearing failures directly affect the production, the customer intended to try some better grease available with less frequent re-greasing & bearing failures and better equipment availability.

The customer therefore asked two suppliers (IOC and another supplier) for suitable substitute of the existing product under use. Both the suppliers offered their high temperature greases for usage in the application area. The performance with IOC's grease (Candidate Grease) was found to give excellent performance whereas the grease of the other supplier (Grease No 2) failed miserably with grease dropping and catching fire due to high temperature exposure.

Performance of Grease No 2

Grease No 2 was experimentally tried in one of the bearings prone to high temperature exposure. The grease was filled manually in the bearing housing (Centralized Greasing System was cut off) and was observed for its performance for one week. This grease however miserably failed to perform in the subject working conditions. The customer faced following problems:

1. Oil from the Grease was coming out of the bearing because of high temperature and was getting exposed to furnace heat.
2. Because of High Temperature Zone, the oil caught fire. Water spraying was done frequently to put off the fire.
3. Bearing failure observed within one week.

TRIAL WITH CANDIDATE GREASE OF IOC

Based on our recommendation, the Candidate Grease was put in use in the application area. The grease was put into use in a new Bearing fitted in the furnace side in Stand No: 89/5 in Furnace No: 4.

TRIAL PERIOD

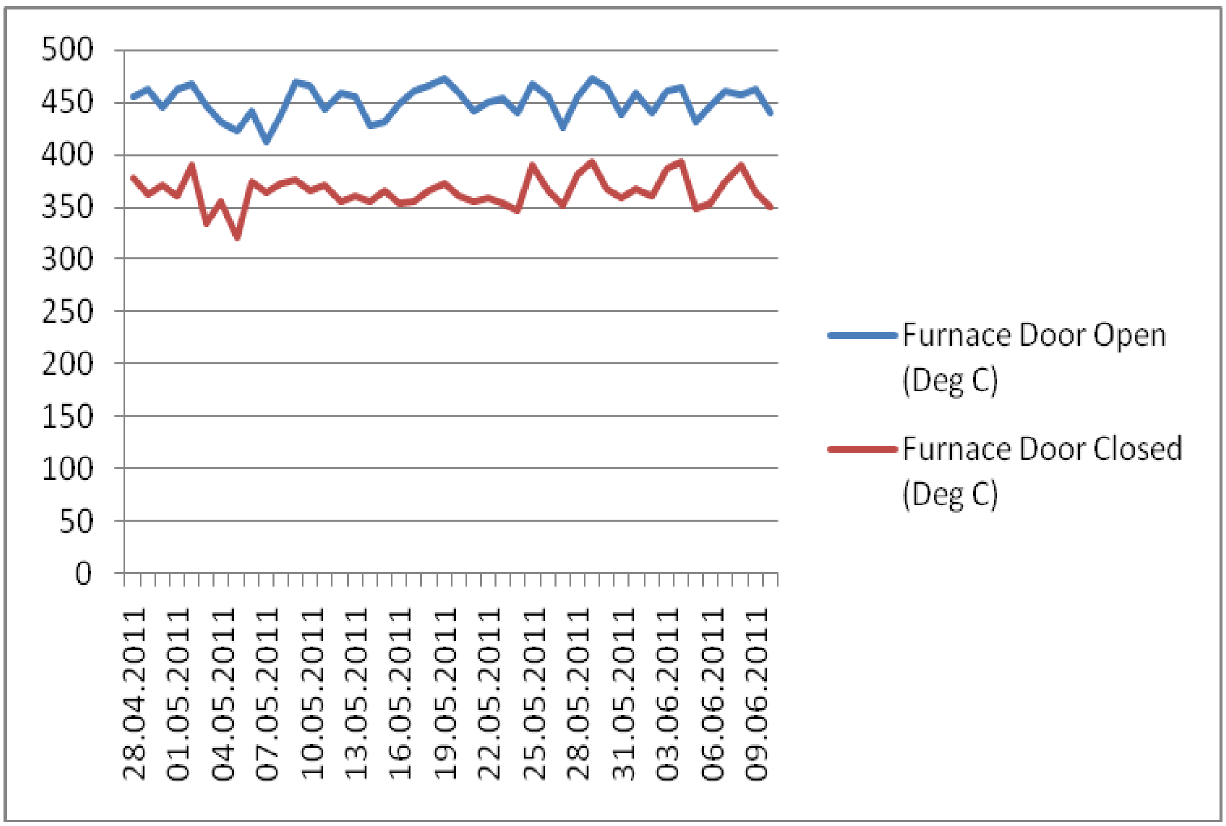
Trial was conducted from 28th April'11 to 10th June'11 (44 days).

METHODOLOGY OF TRIAL:

Approximately 2.5 Kg of the grease was manually filled in the bearing housing. The housing was closed and the bearing was put in use in the stringent working conditions. All centralized Greasing System was cut off.

OBSERVATIONS

1. **Bearing Temperature:** Temperature of the bearing Housing was recorded through Temperature Gun. The Bearing Housing temperature observed during the trial period is attached as Annexure-II.

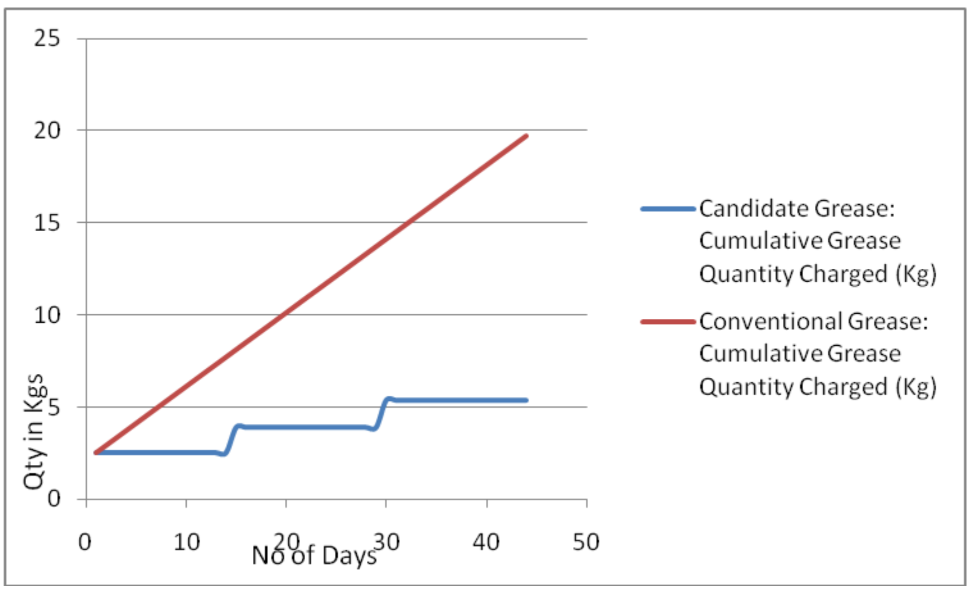


Temperature Profile of the Bearing Housing with Candidate Grease under Trial.

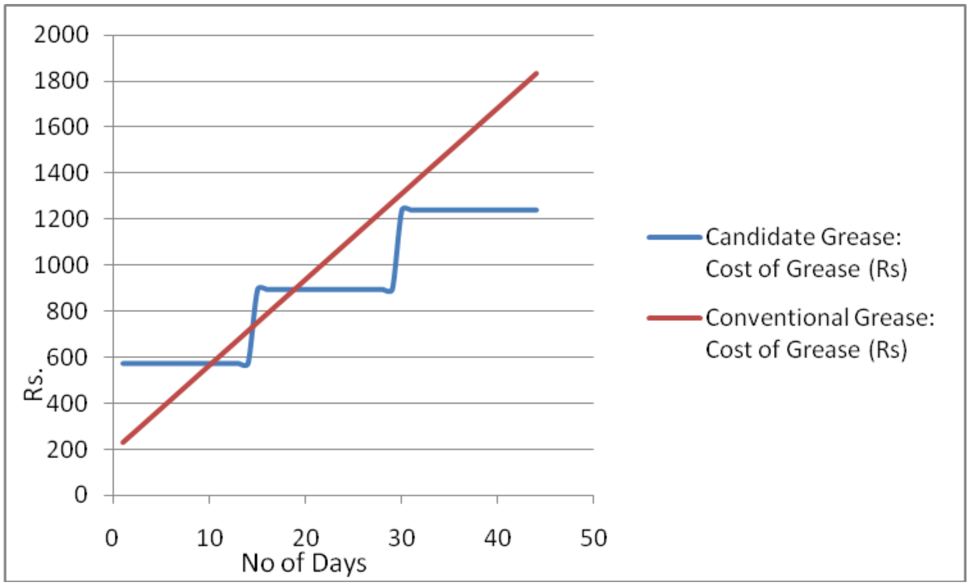
2. **Bearing conditions during the Trial:** The bearing housing was opened after every 15 days during the course of trial and following observations were made:

    a. The Candidate Grease was still there in the bearing housing. Slight make up grease was required to be applied for better lubrication.
    b. The texture of the grease was maintained even after the temperature severity.
    c. There was no case of bearing failure during the trial period.
    d. There was no case of Grease burning during the trial period.
    e. Additional Quantity of Grease was manually charged in the bearings to make up for the losses.

3. **Grease Consumption- Candidate Grease vis-à-vis Conventional Grease:** The Grease Consumption and the Cost of Greasing for the Candidate Grease and Conventional Grease is attached as Annexure III. The Graphical representation of the Grease Consumption and Cost of Greasing for the Candidate Grease and Conventional Grease are illustrated below:



Grease Consumption of Candidate Grease vis-à-vis Conventional Grease



Cost of Greasing of Candidate Grease vis-à-vis Conventional Grease.

Though the Candidate Grease was costlier than the Conventional Grease, the cost of Greasing of the Candidate Grease was much lower as compared to that with Conventional Grease. Further, there was no bearing problem observed with the candidate grease during the course of trial as against the average bearing failure of one bearing per month with the Conventional Grease. Lesser maintenance and bearing failures had resulted in lesser downtime and better equipment availability for production.

INFERENCE

The Candidate Grease was able to withstand the severe temperature condition without any problem. This led to reduction in Bearing failure, improved equipment availability and lesser down time. The frequency of re-greasing reduced from once in a shift to once in 15 days, leading to drastic reduction in grease consumption.

The performance of our grease was well appreciated by the customer.

CONCLUSION

Based on the success of our grease in HSM, the customer has given us order of 45 MT of the product on Proprietary Basis. The grease shall be put into use in Continuous Casting Shop for bearing lubrication.

PRODUCT SPECIFICATION OF THE CANDIDATE GREASE **Annexure-I**

The Candidate Grease has been formulated to withstand High Temperature and EP/ Shock Loads for Boundary Lubrication. The grease has the following Technical parameters:

Property	**Test method**	Result
Appearance	Visual	Homogeneous
Colour	Visual	Dark brown
Penetration @ 25° C, Worked	D-217	265-295
Dropping point° C	D-566	>300
Weld load, kg	IP-239	355

The Candidate Grease has following Performance Benefits;

1. **Excellent resistance to Oxidation.**
2. **Minimum softening and loss of structure at high temperature.**
3. **Excellent resistance to Water Wash out.**
4. **Prevents spot welding and seizure because of shock loads.**

Annexure-II

TEMPERATURE PROFILE RECORDED DURING THE COURSE OF TRIAL

Date	Furnace Door Open (Deg C)	Furnace Door Closed (Deg C)
28.04.2011	456	378
29.04.2011	463	362
30.04.2011	445	370
01.05.2011	462	361
02.05.2011	468	390
03.05.2011	446	334
04.05.2011	431	356
05.05.2011	422	321
06.05.2011	441	374
07.05.2011	412	363
08.05.2011	438	372
09.05.2011	469	376
10.05.2011	466	365
11.05.2011	443	370
12.05.2011	458	356

Date	Furnace Door Open (Deg C)	Furnace Door Closed (Deg C)
13.05.2011	455	360
14.05.2011	428	356
15.05.2011	431	365
16.05.2011	449	353
17.05.2011	461	355
18.05.2011	465	366
19.05.2011	472	372
20.05.2011	458	360
21.05.2011	442	355
22.05.2011	451	359
23.05.2011	454	354
24.05.2011	439	346
25.05.2011	468	390
26.05.2011	456	366
27.05.2011	426	352

Date	Furnace Door Open (Deg C)	Furnace Door Closed (Deg C)
28.05.2011	455	381
29.05.2011	472	394
30.05.2011	464	368
31.05.2011	438	359
01.06.2011	458	368
02.06.2011	439	360
03.06.2011	460	387
04.06.2011	464	394
05.06.2011	431	348
06.06.2011	446	354
07.06.2011	461	375
08.06.2011	457	389
09.06.2011	462	364
10.06.2011	439	350

Annexure III

Grease Consumption of Candidate Grease vis-à-vis Conventional Grease

No of days	Candidate Grease				Conventional Grease			
	Cost of Grease (Rs./Kg)	Grease Quantity Charged (Kg)	Cumulative Grease Quantity Charged (Kg)	Cost of Grease (Rs)	Cost of Grease (Rs./Kg)	Grease Quantity Charged (Kg)	Cumulative Grease Quantity Charged (Kg)	Cost of Grease (Rs)
1	230	2.5	2.5	575	93	2.5	2.50	232.5
2	230	0	2.5	575	93	0.4	2.90	269.7
3	230	0	2.5	575	93	0.4	3.30	306.9
4	230	0	2.5	575	93	0.4	3.70	344.1
5	230	0	2.5	575	93	0.4	4.10	381.3
6	230	0	2.5	575	93	0.4	4.50	418.5
7	230	0	2.5	575	93	0.4	4.90	455.7
8	230	0	2.5	575	93	0.4	5.30	492.9
9	230	0	2.5	575	93	0.4	5.70	530.1
10	230	0	2.5	575	93	0.4	6.10	567.3
11	230	0	2.5	575	93	0.4	6.50	604.5
12	230	0	2.5	575	93	0.4	6.90	641.7
13	230	0	2.5	575	93	0.4	7.30	678.9
14	230	0	2.5	575	93	0.4	7.70	716.1
15	230	1.4	3.9	897	93	0.4	8.10	753.3
16	230	0	3.9	897	93	0.4	8.50	790.5
17	230	0	3.9	897	93	0.4	8.90	827.7
18	230	0	3.9	897	93	0.4	9.30	864.9
19	230	0	3.9	897	93	0.4	9.70	902.1
20	230	0	3.9	897	93	0.4	10.10	939.3
21	230	0	3.9	897	93	0.4	10.50	976.5
22	230	0	3.9	897	93	0.4	10.90	1013.7
23	230	0	3.9	897	93	0.4	11.30	1050.9
24	230	0	3.9	897	93	0.4	11.70	1088.1
25	230	0	3.9	897	93	0.4	12.10	1125.3
26	230	0	3.9	897	93	0.4	12.50	1162.5
27	230	0	3.9	897	93	0.4	12.90	1199.7
28	230	0	3.9	897	93	0.4	13.30	1236.9
29	230	0	3.9	897	93	0.4	13.70	1274.1
30	230	1.5	5.4	1242	93	0.4	14.10	1311.3
31	230	0	5.4	1242	93	0.4	14.50	1348.5

32	230	0	5.4	1242	93	0.4	14.90	1385.7
33	230	0	5.4	1242	93	0.4	15.30	1422.9
34	230	0	5.4	1242	93	0.4	15.70	1460.1
35	230	0	5.4	1242	93	0.4	16.10	1497.3
36	230	0	5.4	1242	93	0.4	16.50	1534.5
37	230	0	5.4	1242	93	0.4	16.90	1571.7
38	230	0	5.4	1242	93	0.4	17.30	1608.9
39	230	0	5.4	1242	93	0.4	17.70	1646.1
40	230	0	5.4	1242	93	0.4	18.10	1683.3
41	230	0	5.4	1242	93	0.4	18.50	1720.5
42	230	0	5.4	1242	93	0.4	18.90	1757.7
43	230	0	5.4	1242	93	0.4	19.30	1794.9
44	230	0	5.4	1242	93	0.4	19.70	1832.1

Performance of EP 000 Grease in Plastic Injection Moulding Machine – A Case Study

S. Kondaguli, A. S. Roy, J. K. George and T. G. Nagarajan

Indian Oil Corporation Ltd, Maharashtra

PLASTIC INJECTION MOULDING PROCESS

The plastic injection moulding process produces large numbers of parts of high quality with great accuracy, very quickly.

Plastic material in the form of granules is melted until soft enough to be injected under pressure to fill a mould. The result is that the shape is exactly copied. Once the plastic moulding has cooled sufficiently to harden the mould opens releasing the part. The whole injection moulding process then repeats.

The plastic material is taken in a hopper and fed into a screw barrel.

The different stages in a plastic injection moulding process cycle are :

CLAMPING - the moving and fixed platens of the injection moulding machine holds the mould tool together under pressure.

INJECTION - the molten plastic that has been melted (at 150 – 170 deg C) from pellet form in the barrel of the moulding machine is injected under pressure into the mould.

DWELLING - after the molten plastic has been injected into the mould pressure is applied to ensure all cavities are filled.

COOLING - the plastic parts are then allowed to solidify in the mould.

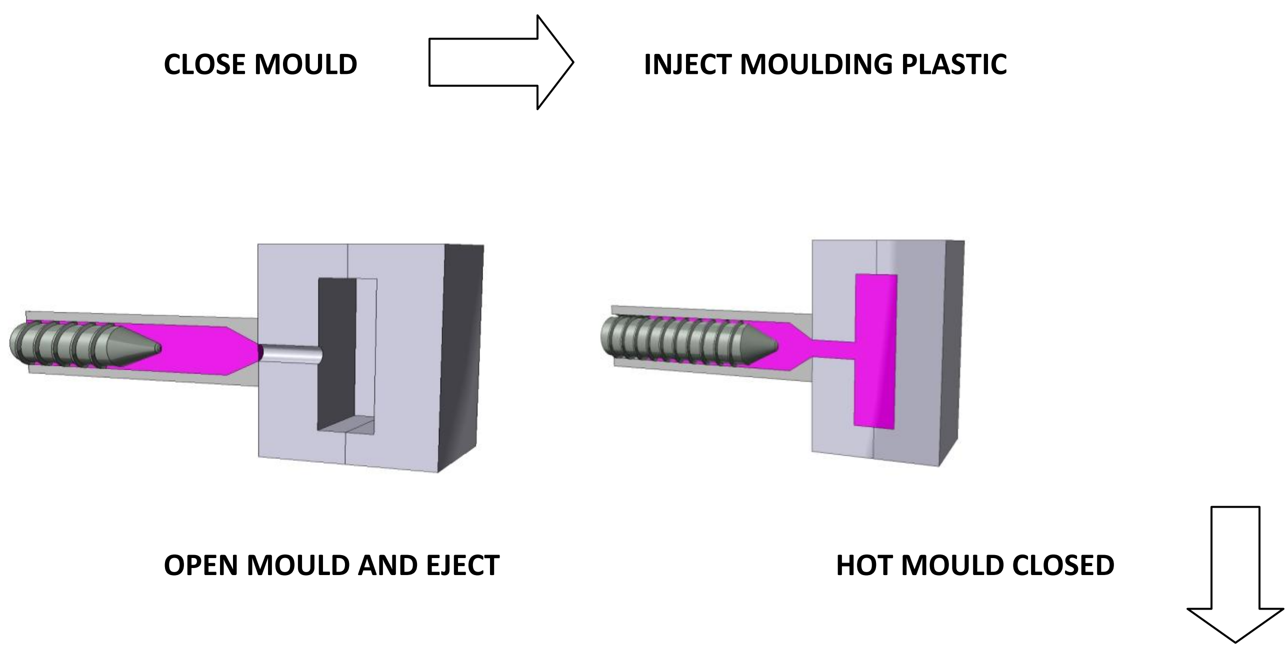
OPENING - the moving platen moves away from the fixed platen (see next section) separating the mould tool.

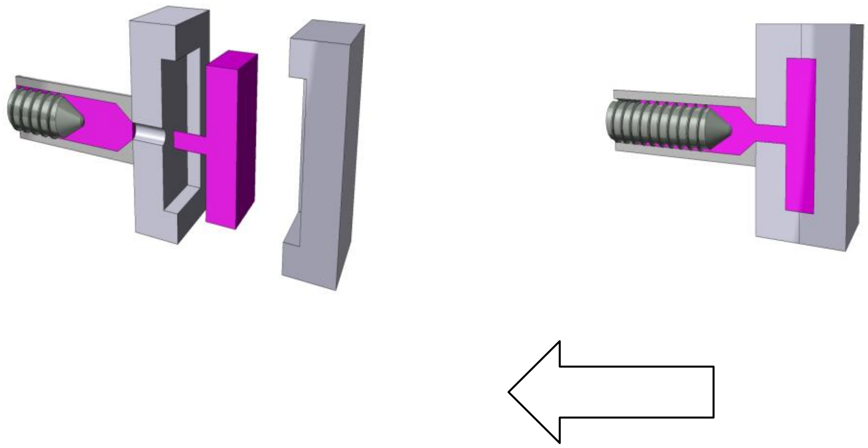
EJECTION - rods, a plate or air blast then aids ejection of the completed plastic moulding from the injection mould tool.

The length of time from closing the mould to ejecting the finished plastic moulding is the cycle.

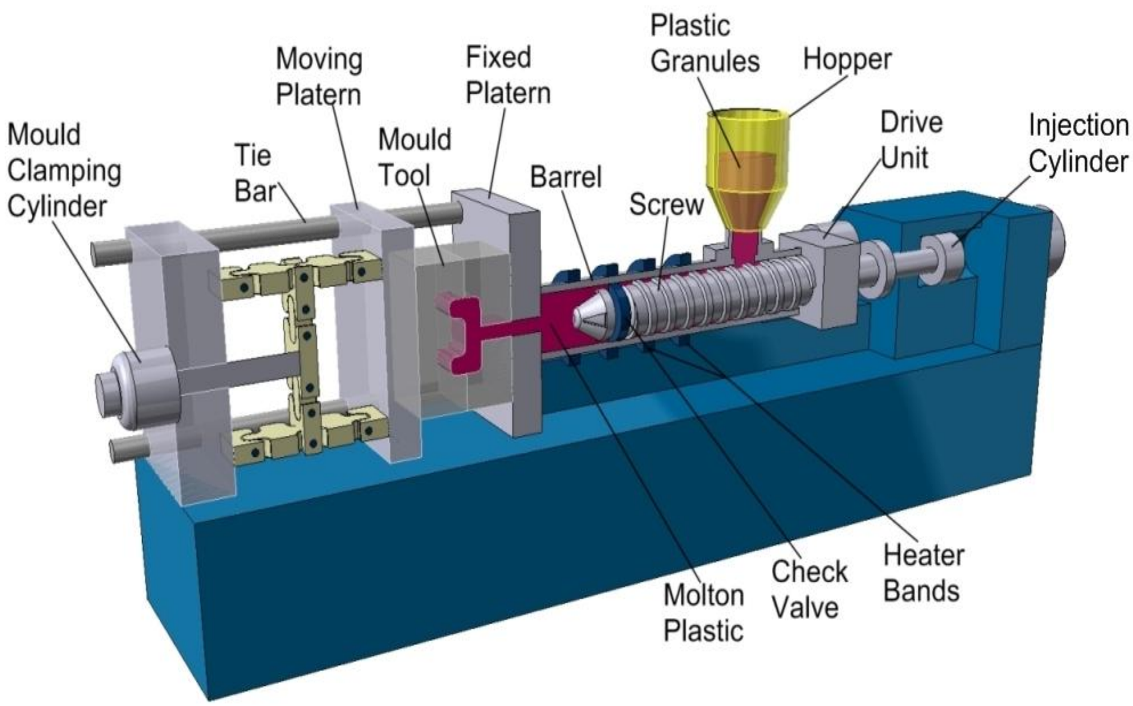
PLASTIC INJECTION MOULDING PROCESS

The above process is illustrated below:





PLASTIC INJECTION MOULDING MACHINE



The clamping end with moving platen opens and closes the mould and supplies sufficient force to keep the mould closed when molten plastic is injected under pressure.

The injection cylinder drives the screw inside the barrel containing the molten granules. The barrel has heater bands around the outside to melt the plastic.

When the right quantity of material has accumulated the screw stops rotating and acts like a plunger moving forward and forcing the molten plastic into the mould tool.

MACHINE DATA – Model Haitan HTF 200X

PARAMETER	UNIT	VALUE
Screw Diameter	mm	80
Calculated injection volume	cm3	1860
Injection Pressure	MPa	158
Injection Stroke	mm	370
Screw speed	r/min.	0-137
Heating i/p power	KW	27.45
Space between tie-bar(HXV)	mm	730X730
Mould opening stroke	mm	700
Ejector stroke	mm	180
Ejector force	KN	110
Grease tank capacity	**Kg**	**6**
Distribution Pressure	**MPa**	**2**

LUBRICATION PARTS

Tie bars

A part of the clamping unit.

It is located between the fixed platen and the moving platen.

The function of a tie bar is to support clamping power

Tie-bar(4nos) **Mould platen which moves on the tie bar**

LUBRICATION PARTS

Toggle link

It supports the moving platen on the base

As a result, there is less strain on tie-bars

Also, it enhances accuracy, smooth platen movement and equal distribution of clamping force

Toggle Link

LUBRICATION

The tie-bars and toggle links are lubricated by grease by a centralized lubrication system. The grease tank is 6 kg and grease is fed at a pressure of 20 bars. The filter is placed in the grease tank. A pump driven by an electric motor feeds the grease to the different lubrication points via distributors.

OEM recommendation is Li – Base, EP, NLGI 00.

Grease Tank (6Kg)

Distributor having very small orifice through which grease is pumped into the tie-bar

PROBLEMS FACED BY THE CUSTOMER

As per OEM recommendation, customer used Li-Base EP 00 Grease.

However, pump filters & distributors getting choked frequently.

Due to non-supply of adequate quantity of grease, toggle link & the tie-bar getting jammed.

ACTION TAKEN BY CUSTOMER

The sealing system was thoroughly checked for possible ingress of external contaminants in to the grease circuit. It was found in order.

The frequency of grease pumping was also changed without any success.

EP 00 Grease from different suppliers were tried out. However, no significant improvement was achieved.

The problem was referred to IndianOil for solution.

OPTIONS EXPLORED BY IOC

Option 1 : Increasing the rating capacity of the motor.

This would lead to increase of injection pressure and modification of the piping & the distributor. Also, there will be increase of power consumption as well as grease consumption.

Therefore, this option was not chosen.

Option 2 : Decrease the consistency of grease without compromising in the anti-wear and weld load characteristics.

This was adopted as it was technically acceptable and easy to implement.

RESULTS

EP 000 grease was introduced in December 2010. No choking problems faced by the customer till January 2012. Lubrication performance of the tie-bars and toggle links are satisfactory. Grease consumption increased by around 11 % over NLGI 00 grease.

POTENTIAL BENEFITS TO CUSTOMER

Machine Downtime = 2 hours, average, Repetition of Machine Downtime = 3 months, average, i.e. 8 hours/year/machine.

No. of machines = 15, Av. Production/hr./machine = 60 articles

Loss of production/year/machine = 8*60 = 480 articles

Loss of production/year = 480*15 =7200 articles

Av. Cost / article = Rs. 100/-

Monetary loss / year = 7200 * 100 = Rs. 7,20,000/-

Consumption of NLGI 000 grease = 2 MTPA

Projected Consumption of NLGI 00 grease = 1.8 MT

Cost of 200 kg extra NLGI 000 grease = 200*176 = Rs. 35200 (considering cost of NLGI 000 grease = Rs. 176/kg)

Additional price/kg of NLGI 000 over NLGI 00 grease = Rs. 4

Additional grease cost/year = 1800*4 = Rs. 7200/-

Total additional cost due to switching over from NLGI 00 to NLGI 000

= Rs. 35200 + Rs. 7200 = Rs. 42400/-

Potential savings to customer = Rs. 7,20,000 – Rs. 42,400 = **Rs. 6,77,600**

SUMMARY

The importance of selection of consistency of grease in centralized grease lubrication system is brought out in this paper.

There is further scope in fine tuning the grease consistency for improving specific grease consumption.

This experience and similar others also highlight the need to bring in additional levels in-between the existing NLGI Consistency Levels to meet the tailor-made requirements.

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Haitan Machine Manual

CONDITION MONITORING OF GREASE - A MAJOR TOOL FOR HEALTH MONITORING & FAILURE AVOIDANCE OF STEEL PLANT EQUIPMENT

B. K. Das, F. Mitra and M. R. Satyanarayana

Tata Steel, Jamshedpur

ABSTRACT

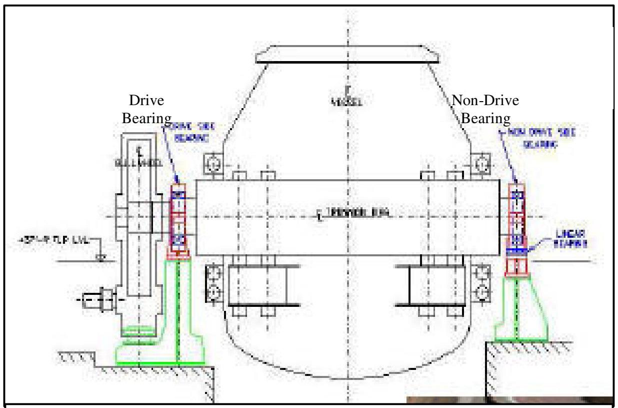
The steel plant equipments are subjected to a very harsh service conditions. The nature of the process & operations subject them to the conditions of high temperature, dust, water, steam and continuous heavy loads. Condition monitoring of these equipment is very vital for smooth and trouble free running. Although, Condition monitoring by Vibration analysis is very useful in many equipment, it does not give early warning in some cases, especially, the slow moving machinery.

Grease Ferrography has recently become a more widely applied technology in machinery health condition monitoring. Wear is the primary mechanism by which rolling element bearings deteriorate. By observing the amount and mechanism of wear periodically, the rate of bearing deterioration can also be monitored. This technique may overcome the particle size limitation and provide additional information on the mechanism, location and extent of wear, and to some degree, the state of the lubricant and any contaminants.

This paper presents one such case where Grease Ferrography has averted a major failure

BACKGROUND

The BOF converter in one of the steel melting shops, LD2, of TATASTEEL is having a heat size of 160 Ton. This converter is a contrivance in which steel is melted, with the addition of Hot metal, scrap & fluxes. The converter is required to be tilted either way for charging / tapping of material. To facilitate the rotation of the vessel, an electro-mechanical drive with PLC control is provided. The converter rotates about bearings, one each on the drive and non-drive end. These are huge double row spherical roller bearings of 850 MM ID. Failure of these bearings would bring the production to a grinding halt and the recovery period is also too long. Ensuring the reliability of these bearings is an area of concern.



Schematic of BOS Vessel and Bearing

EXISTING SYSTEM

There was a catastrophic failure of the drive bearing of Vessel # 2 in May'09 which led to an outage of the vessel for 44 days.

During that time,

1) There was no internal inspection system for these bearings.

2) There was no established CM for these bearings. (Vibration analysis is not useful as the vessel rotates at 1(one) RPM only.

3) Bearings were replaced at a pre-defined life.

The goal is to improve the reliability of these bearings (10 bearings are in service at LD1&2) by having a system of early detection of abnormalities.

OVERVIEW OF FERROGRAPHY

Ferrography is a means of microscopic examination used to analyze particles separated from fluids. Developed in 1971, it was initially used to magnetically precipitate ferrous wear particles from lubricating oils. The success of this technique in monitoring the condition of military aircraft engines led to further developments for other practical uses. One such development was a modification to precipitate nonmagnetic particles from lubricants and other fluids. Today, in a wide range of industries, Ferrography can be valuable in helping to determine the maintenance needs for machinery by identifying the specific conditions of machine Figure 1 The DR-V Ferrograph™, a direct reading Ferrograph, measures the concentration of wear particles.

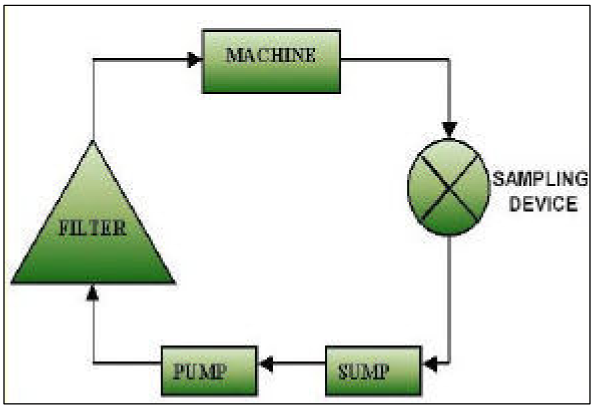
THE PHYSICAL SYSTEM

Ferrography is tool for wear particle analysis which is a powerful technique for non-intrusive examination of the oil-wetted parts of a machine. The parts contained in the lubricating oil carry detailed and important information about the condition of the machine. This information may be deduced form particle shape, composition, size, distribution and concentration. The particle characteristics are sufficiently specific so that the operating wear modes within the machine may be determined, allowing prediction of the imminent behavior of the machine.

FERROGRAPHY SYSTEM DESCRIPTION

The Ferrography analysis of a system consists of the following steps:

1. **Collection of representative sample:**



Sample is collected after the machine and before the oil goes to the sump so that the oil does not pass through the filter and wear debris does not settle down in the sump. It is desirable to take the sample during known operating conditions. It has been observed that the particle concentration in the lubricating oil varies significantly high and low power settings in case of diesel engines and gas turbines. Again the effect of oil change must be considered because of the time to regain equilibrium particle concentration. Each material will have a characteristic operating time to return to its normal equilibrium level which is governed by the particle removal mechanism.

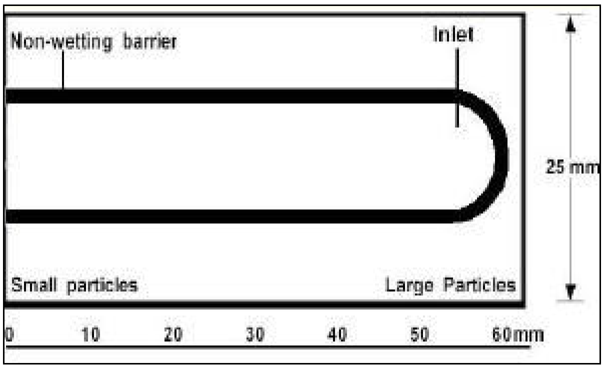
Factors which influence the operating time to equilibrium are:

- Filtration, i.e., the number of times a particle of a given size and material may, on an average, pass through the filter.
- The oil pumping cycle rate. This rate is the pumping rate expressed in volume per unit time divided by the volume of lubricant in the system.
- Dispersive qualities of the lubricant.

Sampling is done from a single location in the system because different parts in a system may have different particle concentration. It is desirable that sample is taken from pipe carrying oil scavenged from the wearing parts.

2. Preparation of Ferrogram

Here the particles are separated on treated glass which due to its placement in a special very high gradient magnetic field causes the particles to be sorted according to size. The largest are deposited first, while the smaller ones travel further with the flowing oil.

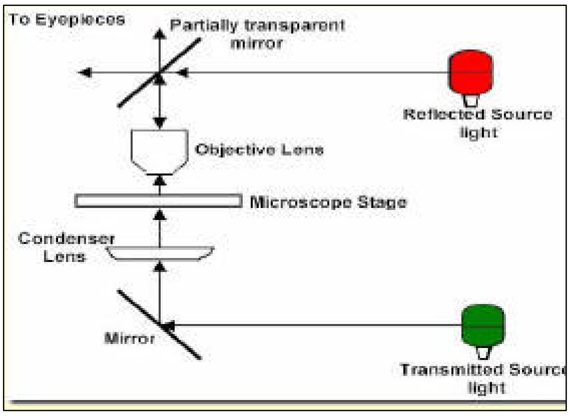


3. Ferrography It consists of

a) DR (Direct Reading) Ferrography

It is quick method for which direct reading of the wear index SD can be achieved in 5 minutes. In this, a controlled flow of oil passes through a calibrated glass tube which is mounted in a specially designed magnetic field. The separation process causes the particles to be sorted by size at the bottom of the tube.

b) Analytical Ferrography:



Light Path for Bi-chromatic Microscope

Analytical Ferrography is done using Ferroscope, which is a bi-chromatic microscope

Microscopic examination for analytical Ferrography can be carried out with various types of illumination:

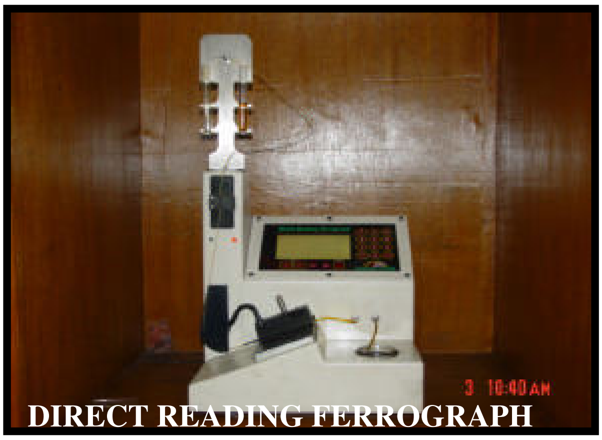
- Reflected White Light
- Transmitted White Light
- Polarized Light
- Bi-chromatic Light

These various forms of light cause some of the characteristics of the wear particles to be emphasized: form, colour, size and composition. The bi-chromatic microscope utilizes two sources of light: a green one and a red one. The green light is transmitted through the sample and the red light is reflected from the surface. The pure metal particles appear bright red, while the oxide particles and the other metal compounds permit much more light to be transmitted. These particles will, therefore, depending upon their thickness, appear to be green, yellow or pink.

Heating the Ferrogram and use of temper colors:

Heating the Ferrogram to various temperatures makes it possible to distinguish between particles of soft steel, cast iron, nickel and stainless steel due to the various tarnishing colors of the material.

FERROGRAME MAKER



DIRECT READING FERROGRAPH

GREASE FERROGRAPHY

To apply the techniques of Ferrography to grease-lubricated bearings, a solvent system had to be developed that would dissolve the grease sample and produce a fluid of viscosity suitable for preparing a Ferrogram. The system also had to be capable of demonstrating that the particles found in the grease are accurately represented in the fluid sample. Because the ingredients used in grease formulations are diverse, the selection of a single solvent for all greases appeared to be a difficult task. Solid additives incorporated in greases are insoluble. Differences in manufacturing procedures may cause differences from manufacturer to manufacturer, and different manufacturers with the same specifications may use different soaps or thickeners. For example, one manufacturer may use a soap base to thicken a specific lubricating fluid, while another may incorporate the soap-making procedure in the grease manufacturing process. The concentration, distribution, and size of the solid phases may also vary.

It was therefore necessary to establish a reliable technique for sampling grease and to select solvents that could be used to dissolve greases of all types. It was also necessary to demonstrate that once a sample of grease had been treated with a suitable solvent, the same Ferrographic techniques could be used as those successfully applied to samples of lubricating oil. Unused samples were obtained for the nine greases listed in Table I. These Greases cover a range of fluid lubricants, soap phases, and solid Additives.

Three solvent systems were initially chosen for solution studies on these greases. Because the ability of a solvent system to dissolve different materials cannot be accurately predicted, the two solvent systems chosen had varying balances of polar, non-polar, and aromatic or aliphatic constituents.

Sample No.	Base oil	Thickener	Solids	Solvent # 1	Solvent # 2
1	Mineral	Li. Complex		Fixer oil	Diluent oil
2	Mineral	Li. Complex	MOS2	Fixer oil	Diluent oil
3	Mineral	Ca. Complex		Fixer oil	Diluent oil
4	Mineral	Ca. Sulphonate		Fixer oil	Diluent oil
5	Mineral	Al. Complex		Fixer oil	Diluent oil
6	Mineral	Al. Complex	MOS2	Fixer oil	Diluent oil
7	Mineral	Li – Ca Mixed base	MOS2	Fixer oil	Diluent oil

DESIGN OF EXPERIMENTS

1 gm of each grease was dissolved in 50 ml of the solvent

A total of 14 Experiments were conducted to observe the solvency of various greases in these solvents by visual examination

It is seen that both the solvents were able to completely dissolve the grease in 4-5 hrs time

CHALLENGES IN GREASE FERROGRAPHY

- Collection of representative sample.
- Ensuring consistency of sampling
- Ensuring complete dissolution of sample in the solvent (Choosing the right solvent)
- Complexity of slide preparation
- Time consumed in the complete cycle of Ferrography.

GREASE FERROGRAPHY IN TATASTEEL

To overcome those challenges, TATASTEEL has developed a “Standard Work procedure” for grease Ferrography from sample collection to analyzing the results.

The broad steps include:

- Sample collection from different locations
- Homogeneous mixing of samples at 65°C
- 1 gm of Grease to be dissolved in 50 Ml of solvent for 5 Hrs
- 5 ml of sample for slide preparation
- Slide heating up to 300°C.
- Microscopic examination

CASE STUDY OF GREASE FERROGRAPHY IN TATASTEEL

INCIDENCE	**Failure of DE Bearing**
Department	LD2 & SC
Section	Vessel
Location	Vessel # 2
Date	28/05/2009

The BOF converter in one of the steel melting shops, LD2, of TATASTEEL is having a heat size of 160 Ton. This converter is a contrivance in which steel is melted, with the addition of Hot metal, scrap & fluxes. The converter is required to be tilted either way for charging / tapping of material. To facilitate the rotation of the vessel, an electro-mechanical drive with PLC control is provided. The converter rotates about bearings, one each on the drive and non-drive end. These are huge double row spherical roller bearings of 850 MM ID. Failure of these bearings would bring the production to a grinding halt and the recovery period is also too long. Ensuring the reliability of these bearings is an area of concern.

OBSERVATIONS:

After up-gradation, there was problem of grease melting out from the bearing in vessel#1 because of the use of Grease A initially suggested by Company. Afterwards, with the use of Grease B, which is proven for the application, problem was solved. Vessel#2 Trunnion bearings were greased with Gr B from the beginning after up-gradation.

The bearing was in operation for only 18 months since commissioning on 22.11.07 during Up-gradation. The failed bearing is located bearing. The NDE bearing is floating bearing having allowable float of 50 mm (+/- 25 mm). Vessel#2 had given already 3,500 heats in the ongoing campaign till the bearing failure was observed. In the previous campaign (just before the ongoing campaign), vessel#2 had given record heats of 5000. On an average, heat obtained in one campaign per vessel is around 4000 heats.

On 28th May'09, during daily inspection, at around 10 am, it was discovered that, the top half of the seal retaining plate and the seal of the drive end (DE) Trunnion bearing of Vessel#2 (Fig.1&2) had come out (fig.3&4). Seal was found damaged. It was observed that all the rollers had accumulated at the bottom of the bearing.

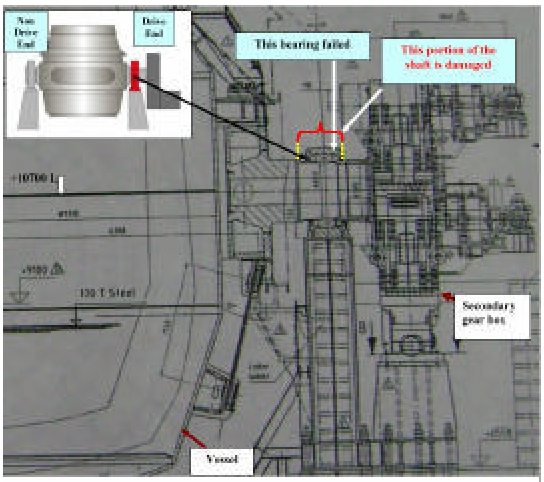


Fig.1: General Arrangement of Tilt Drive of Vessel

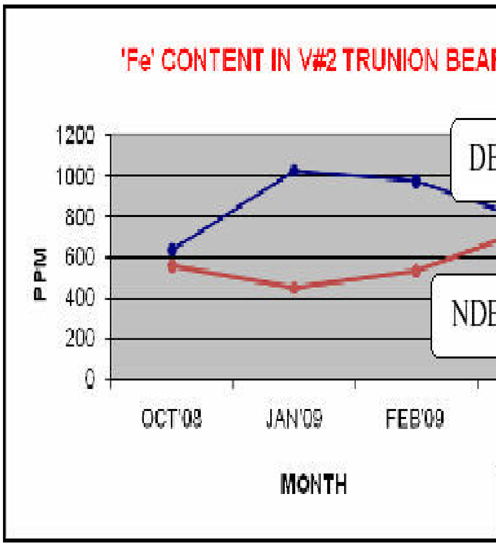
It was also observed that the grease had also accumulated in the bottom of the bearing.

Grease collected from the bottom of the bearing was found having full of particles and broken pieces. Severe irreparable damages have occurred to the Trunnion pin, housing and bearings as shown in the photographs.

Used grease is B. This is extremely high viscosity, mineral oil based grease using a Li-Ca soap containing MoS_2 and graphite. Base oil viscosity at 40 deg c is 1020 mm2/s. Since, September'08, SOAP test was used for condition monitoring of bearing grease. SOAP Test results of March'09, are shown in Table – 1 & Graph – 2. In soap test data, it was found that. Fe content in the grease was abnormally fluctuating in the vessel #3 Trunnion bearings. In vessel#2 bearing, %Fe was also found increasing. Soap tests were done till March'09 and there was no testing after that till the failure since the machine was down till June'09

V # 2			
19-03-09		19-03-09	
Element	DE	Eleme	NDE
Mg	18	Mg	23
Al	84	Al	87
Ca	0.24%	Ca	0.25%
V	<1	V	<1
Cr	3	Cr	2
Mn	8	Mn	2
Fe	760	Fe	750
Ni	44	Ni	39
Cu	3	Cu	1
Zn	0.15%	Zn	0.15%
Mo	0.89%	Mo	0.89%
Cd	<1	Cd	<1
Sn	92	Sn	95
Pb	15	Pb	13

TABLE # 1



Graph.2

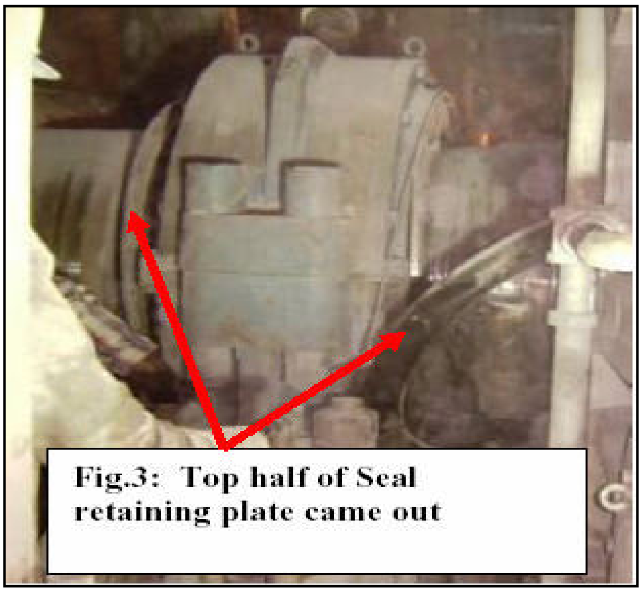


Fig.3: Top half of Seal retaining plate came out

Fig.4: Damaged seal came out

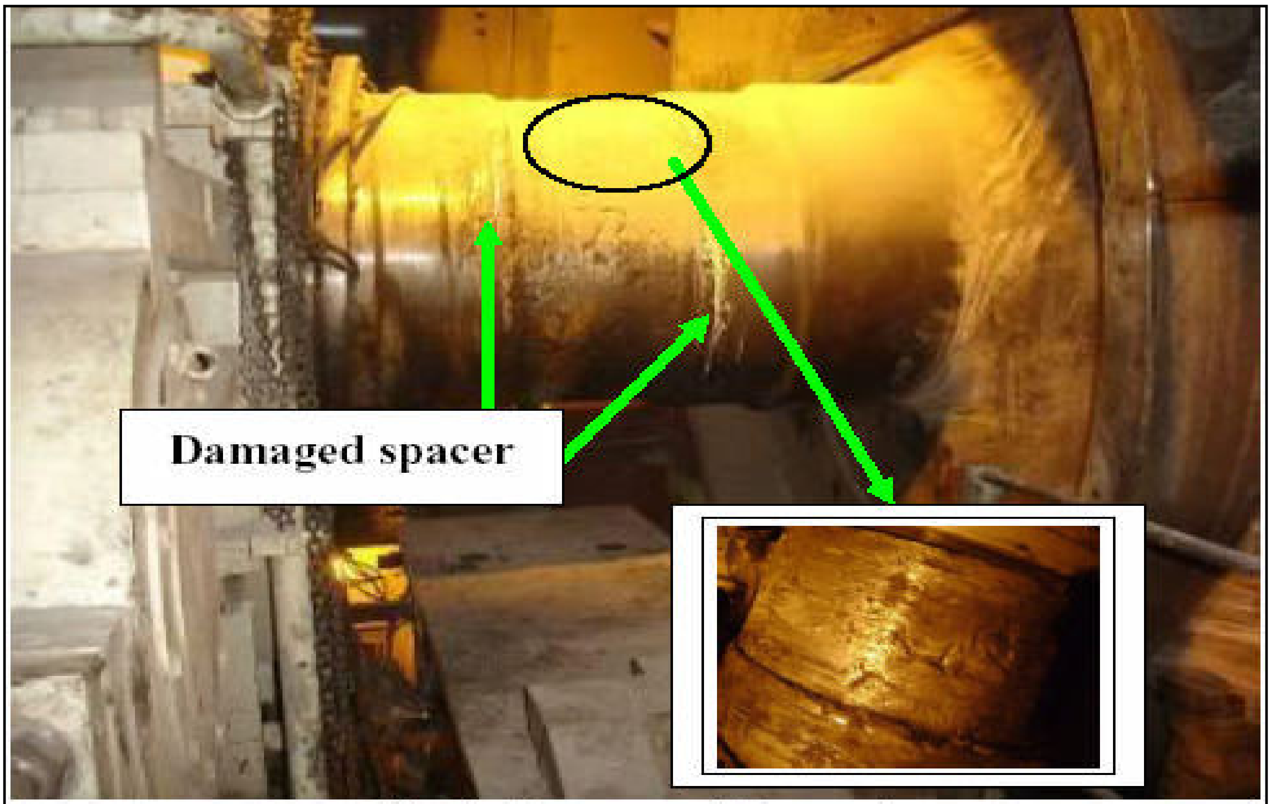


Fig.8: Damage of journal
(Severely scored unevenly all over the periphery)

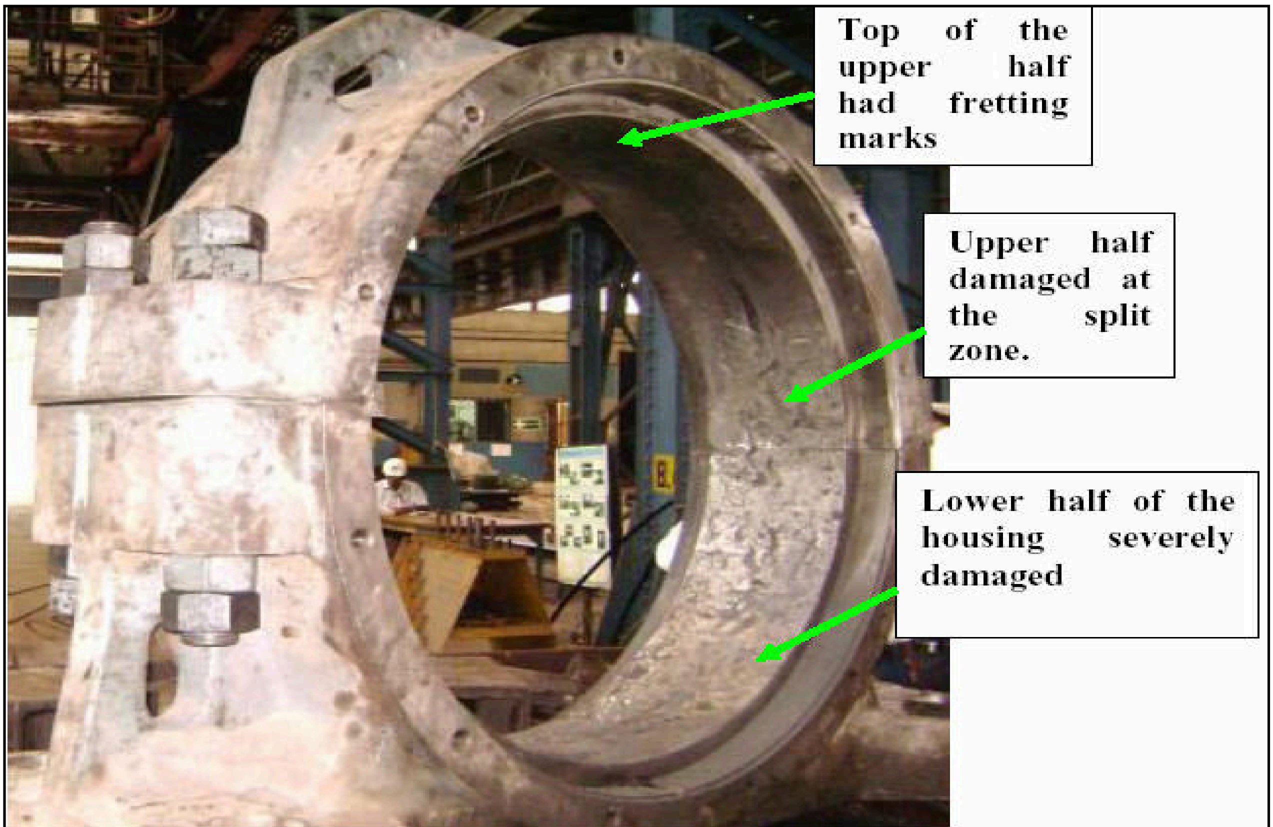


Fig.9: Damage of bearing housing.

The investigation team has given the following recommendations which include grease Ferrography (Point # 2)

S.N	Recommendation
1	100% compliance of recommendations of M/s OEM should be followed with regards to **flushing of bearing grease, seal changing, misalignment checking and float checking.** (As mentioned in this report under the heading of OBSERVATION along with the modified maintenance practices attached as Annexure-6)
2	**Ferrography of the grease should be explored** and to be done monthly along with SOAP test. The trending of the results of these tests should be maintained and reviewed.
3	**Indicators** to be provided to monitor: a) Change in the position of non drive end bearing in axial direction and b) Change in vertical direction at the bull gear bottom with respect to the torque support. The initial reading should be taken for both the above indicators and recorded. It should be reviewed during the end of the campaign life of each vessel.

FAILURE PREVENTION USING GREASE FERROGRAPHY

In the Ferrography report of DE bearing of the same Vessel # 2 at LD # 2, dated 21.09.10 bearing wear particles of 40-50 micron and 20-30 micron and many copper alloy wear particles of 80- 100 micron and 50-70 micron were observed.

Ferrography report of 28.09.10 revealed many 600-800 micron bearing wear particles and many copper alloy wear particles of 200-300 micron were observed.

Accordingly, shut down was taken on 29.09.10 for inspecting the DE bearing and the bearing was found to be on the verge of failure

CONCLUSON

By doing "Grease Ferrography" of bearings, catastrophic failures were averted at two other locations i.e. Vessel # 2 of LD # 1, Vessel # 2 of LD # 2 where the failure was detected in time and corrective actions were initiated. (Refer Annexure # 1 & 2) **Potential saving:** 40 Days of vessel which amounts to Rs. 88 Crores.

Grease Ferrography is now used as a CM tool for most of the slow moving machinery like

- Slew Bearings of Ladle Turret
- Slew Bearings of Kilns & Drums
- Furnace Rolls of CGL
- Sinter cooler & Crusher Bearings
- Stacker * Reclaimer Bearings Etc

Annexure 1

Head Maint
LD 2 SC

MED (M) / LUB / [redacted]
Date : 21-09-2010

We have received grease sample for the condition monitoring . Our observation and recommendation as per the sample is as follows.

Location	Observation	Recommendation.
Vessel 2 Drive Side	Bearing wear particles of 40-50 micron and 20-30 micron observed. Many copper alloy wear particles of 80-100 micron and 50-70 micron observed.	Wear particles more than previous sample. Increase the frequency of greasing of the system for the removal of generated wear particles.
Vessel 2 Non Drive Side	Bearing wear particles of 30-40 micron observed. Few Copper alloy wear particles of 30-40 micron observed.	Wear condition ok.

Sr Manager
MED (M)

Copy :
Head MED (M) → Ferrography

Annexure 2

Head Maint
LD 2 SC

MED (M) / LUB / [redacted]
Date : 28-09-2010

We have received grease sample for the condition monitoring . Our observation and recommendation as per the sample is as follows.

Location	Observation	Recommendation.
Vessel 2 Drive End Trunnion Bearing.	Many 600-800 micron severe sliding bearing wear particles and many copper alloy wear particles 200-300 micron observed.	**Wear particles more than normal. Indication of abnormal wear in the bearing. Inspect the bearing as early as possible.**

Sample Date 28-09-2010

Sr Manager
MED (M)

Copy:
Head MED (M) → Ferrography