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Reduction In Mill Chock Bearing Failures At Merchant Mill- A Case Study From Tata Steel

GRP Singh
Head Fluid Power , MEG, Tata Steel Ltd

Sandeep Bhattacharyya
Technical Support Specialist, ExxonMobil Lubricants Pvt Ltd

Abstract

The Merchant Mill was established in the year 1958 to produce long products ie TMT bars. Tata Steel Merchant mill has 14 rolling stands. Mill Chock Bearing Assembly consists of 4 row Cylindrical Roller Bearing and 2 row Angular Contact Ball Bearing on non-drive end and 4 row Cylindrical Roller Bearing and single row Deep Groove Ball Bearing on drive end.17 Chock Bearing failures were reported in FY-12 in Merchant Mill. On an average each bearing failures leads to about 4-6 hours delay in production. Each hour of delay leads to loss of approximately 55 tons production. One of the major reasons of bearing failure was found to be improper lubrication. A Speciality Grease (ISO VG 460 with Lithium complex thickener, polymer fortified and NLGI 1 grease) was recommended for roughing and intermediate stand (stand no 1 to 10) work roll bearing application through centralized lubrication system. After implementing the recommendation, Merchant mill was able to reduce the grease consumption by 38% and bearing failure was reduced by 70% with increase in productivity with savings INR 3300400 (US$ 55000).
Present paper deals with trial of the new grease and benefits achieved at Merchant Mill of Tata Steel.

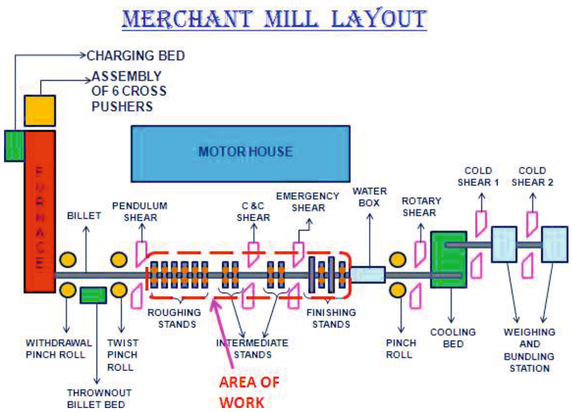
Introduction

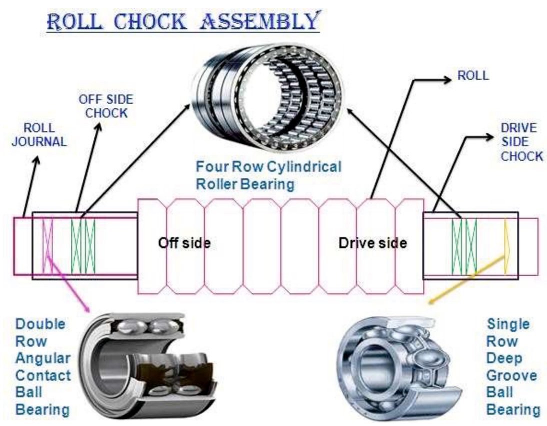
Tata Steel Ltd & ExxonMobil Lubricants team jointly completed the project of bearing failure reduction in Merchant Mill stands work roll bearings. Based on detailed investigation, this report was completed aspart of Planned Engineering Service (PES) program. The performance monitoring of grease was started after detailed study of the application, historical data collection and grease comparison study between old and new grease in the application.

Situational Background

The purpose of Merchant mill is to produce TMT (Thermo Mechanically Treated) bars. The mill uses billets of three different qualities i.e. 500 D (Ordinary quality steel), SD (Super ductile) and CRS (Corrosion Resistant Steel) that are casted in LD #1. It rolls billets having cross-section (130×130) mm2 and length 9m into TMT bars having a wide range of diameters i.e. 20mm, 22mm, 25mm, 28mm, 32mm, 36mm and 40mm by the process of Hot Rolling. The mill has a total production output of about 0.4 MTPA. Tata Steel Merchant mill has 14 rolling stands. All are horizontal stands except 15, 17 which are vertical stands. In roughing and intermediate stand work roll bearing lubrication application, Tata Steel Ltd was using Calcium

Sulphonate thickener based mineral oil ISO VG 320 grease. Due to the continuous passing of red hot billet through work roll, heavy water spray off is used in the application to cool down the bearings. As a result grease was not staying on the bearing and it was getting washed out from application to the floor. Tata Steel had 17 bearing failures in the whole year 2012 due to above reason. Also grease consumption was very high, ~ 8 drums per month. Grease was transferred from drum to application by centralized lubrication system (CLS) with the pump pressure of 110 kg/cm².





Recommendation

Detailed study of the application and suffering points were diagnosed. Tata Steel decided to use a new generation grease of base oil viscosity 460 cst at 40 deg C with Lithium complex thickener NLGI 1 (centralized lubrication system) for roughing and intermediate stand work roll bearing application. Tata steel and grease manufacturer did a detailed competitive study between the existing and new grease which is as follows:

Summary of test parameters and fresh grease comparison

Sr.N.	Parameters	Test Method	New Grease	Existing grease
1	Base oil type		Mineral	Mineral
2	Thickener type		Li- complex Polymer fortified	Organic base
3	Base oil viscosity at 40 deg C	ASTM D 445	460 cst	320 cst
4	Penetration 60X	ASTM D 217	280	292
5	Shear Stability, Extended penetration 100K	ASTM D 217	285	323
6	Timken OK load test	ASTM D 2509	50lb	55lb
7	Bearing protection ability	FAG FE9 DIN 51821	110hrs	40hrs

For more accurate comparison of properties of both the greases, Tata Steel took NLGI 2 grease in both the cases because the existing grease used in the mill was NLGI 2.
The new grease demonstrates better shear stability performance over the existing grease formulation, as indicated by the extended penetration (ASTM D217, 100K strokes).
The new grease demonstrated superior performance in FE9 at 140°C bearing life test compared to existing grease. The new grease achieved 110 hrs compared to 40 hrs for the old Grease.

In terms of load bearing capability both the greases have almost same value as measured by Timken OK load test.

After implementing the same, Merchant Mill was able to reduce the grease consumption by 38% andbearing failure by 70% with increase in productivity.

Due to the below four (4) reasons, Tata Steel achieved the above benefit.

1) Reduced bearing failure
2) Reduced grease consumption
3) Excellent grease pumpability through centralized lubrication system (CLS)
4) Enhanced safety and environment friendly operation

1. Reduced Bearing Failure

Very good water tolerance helps to maintain consistency which can lead to increased bearing life andreduce corrosion related failures. Optimum base oil viscosity provides increased bearing protection even at high temperature operation.

Used old grease in Roll Chock

Used new grease in Roll Chock

2. Reduced Grease Consumption

The new grease is an excellent choice for extreme conditions like moisture environment, high temperature, and shock load in steel mills applications. The polymer fortified Lithium complex technology is giving excellent tenacity. The new grease is adhesive in nature which is providing improved water spray off resistance and excellent lubricantendurance.

High pressure water exposure of bearing in the Mill

New grease showing good tackiness

Outstanding mechanical stability

The proprietary Lithium complex thickener is highly resistant to mechanical shear which contributes less softening of grease and reduced leakage even in the presence of water.

A used grease sample of both the grease was sent to Lubricants Technical Support (LTS) Laboratory, Sarnia, Canada for analysis. The result shows that there is no measurable shear observed in the new grease even after work in actual plant application.

The detail result is as follows:

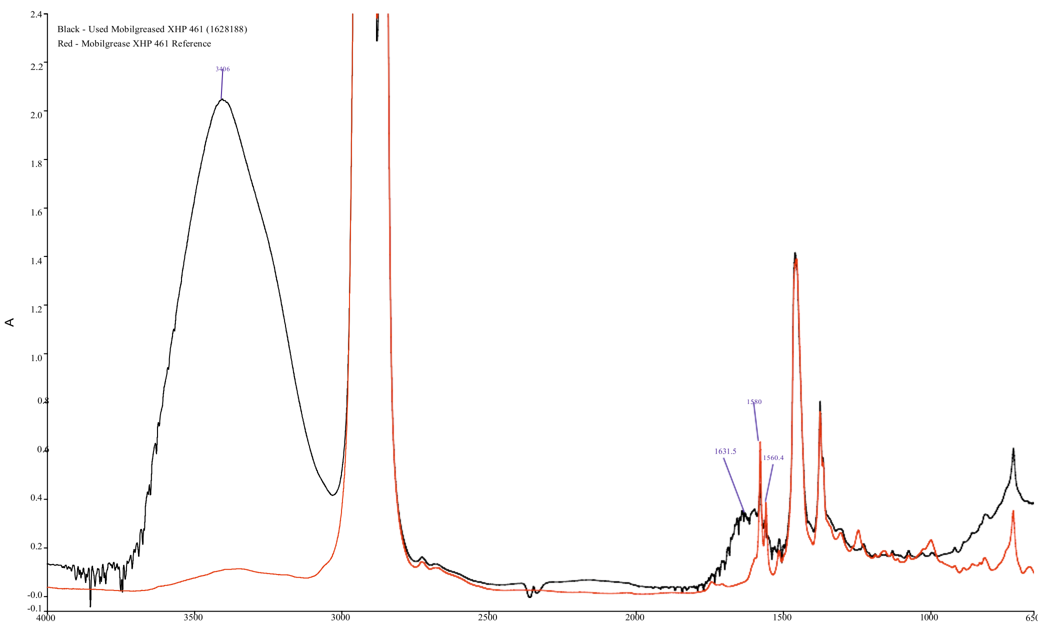
Table 1
Analysis Summary of used Grease Samples Submitted

Test		
Product	**New Grease**	**Old Grease**
Sample Description	Used Grease	Used Grease
Appearance	Free Water, Smooth, Non-Homogenous	Free Water, Some Fine Grit, Non-Homogenous
Karl Fischer Water, %	14.4%	30.5%
60x Worked Penetration (1/2 scale), mm/10	323	323
Water Washout 79C (average wt. Loss), %	18.9	44.5
Elemental Analysis by XRF (wt %)		
Aluminum	Trace	0.01
Calcium	0.05	1.08

Chlorine	0.01	0.01
Copper	0.01	Trace
Iron	0.02	0.25
Magnesium	0.01	0.01
Manganese	Nd	Trace
Nickel	Trace	Trace
Phosphorus	0.1	0.04
Potassium	Trace	Trace
Silicon	Trace	0.01
Sodium	0.05	Nd
Sulphur	0.81	0.83
Zinc	0.19	Trace

Note: XRF results are semi-quantitative. Only elements detected are reported. Nd = not detected. Trace = very low detection that cannot be accurately quantified

Figure 1 - FTIR Spectral Overlay of the Used new grease Sample (1628188, in Black) and a Freshnew grease Reference (in Red)



The used/in service samples submitted were analyzed to determine their properties and conditions and are shown in table 1 above. Both samples received showed free water contamination which was observed as well in several of the completed tests.
Water wash out testing was completed in accordance to ASTM D1264. Each sample is placed in a test bearing the before weight is calculated. Water is sprayed onto the bearing for 60 minutes at 79 deg C. After the sample is dried for 15 hours, the weight loss is calculated. The value reported is an average of the percentage of grease lost in three runs of the test. It should be noted that due to the high water content of the samples submitted, these results may be higher than typical results from fresh or unused grease. Based on the samples submitted the used new grease showed better water washout performance compared to the competitive used grease.
Elemental analysis was completed using X-Ray Fluorescence (XRF). The new grease results are similar to the typical properties of this grease except for the presence of sodium. This could be due again to the water contamination. Both samples showed some wear metals (iron, copper and aluminum) but inrelatively minor quantities.
The used new grease submitted was analyzed as received by infrared spectroscopy (FTIR). In Figure 1, the FTIR spectrum of the used new grease sample is shown overlain with a fresh reference new grease spectrum. The two spectra show the similarity of the lithium complex thickener, however due to the gross water contamination in the spectrum of the used sample some variations were observed

3. Excellent grease pumpability through centralized lubrication system

NLGI 1 new grease has very good pumpability even at low temperature condition. As a result

grease can reach at every places of the application for better bearing protection.

Grease pump for Centralized grease system

4. Enhanced safety and environment friendly operation

4.1 Less grease consumption means less slippage hazards

A large amount of grease getting into the system means large amount of grease disposed in thesurrounding areas presenting more slippage hazards to mechanical maintenance team. By decreasing grease consumption, slippage hazards will decrease significantly

4.2 Less bearing failure means increased human safety

More number of bearing failure means more manpower involvement to the running equipment.

By decreasing number of bearing failure, human safety is increased significantly.

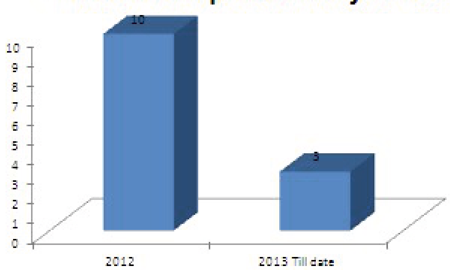
4.3 Less waste grease means more environment friendly operation

High consumption of grease means more waste grease disposed and accordingly more impact on environment.

CONCLUSION

After implementing the polymer fortified Li complex new blue grease recommendation, Tata Steel Ltd Merchant mill was able to reduce the grease consumption by 38% and bearing failure by 70% with increase in productivity for an annual savings of INR 3,300,400 (US$ 55000).

- ✓**Reduced bearing failure (10 nos. in 2012 to 3nos. in 2013 till date for stand 1 to 10)**
- ✓**Reduced grease consumption (8 barrel/month to 5 barrel/month)**
- ✓**Enhanced productivity of the mill**



Merchant Mill Bearing Failure: Stand 1 to 10

MONETARY SAVING		
Revenue Enhancement	Productivity increase	Rs 3,080,000
Expenditure Reduction	Reduced grease consumption Reduce bearing failure	Rs 220,400
	TOTAL SAVING PER YEAR	Rs 3,300,400

Use of New Grease is now extended to all the Mill Stands from 1st December, 2013.

Evaluation of borate esters in lithium complex greases prepared with hydrogenated castor oil.

Vijay Deshmukh, Bhupendra K. Rajput
Standard Greases & Specialities Pvt. Ltd.

Abstract:

Traditionally, lithium complex greases are prepared using complexing agents such as boric acid, sebacic acid, azelaic acid etc. to boost the dropping point of lithium base greases to around 260°C. These complexing agents are added in the initial stage of soap making. The process of lithium complex grease making using these complexing agents is tedious, time consuming and not very flexible.

The advent of Boron Esters as drop point boosters has made the lithium complex grease making process very simple, less time consuming and economical. The commercial boron esters are recommended in lithium base greases prepared using 12 hydroxy stearic acid (12 HSA) and these boron esters are added at the final stage of the process before homogenization and at temperatures below 100°C, like any other performance additives.

This paper describes the evaluation of some commercially available boron esters as dropping point boosters in lithium base greases prepared using hydrogenated castor oil(HCO) in place of 12 hydroxy stearic acid(12 HSA).A special manufacturing process has been developed to incorporate boron esters in lithium greases prepared with HCO to get higher dropping points. One such additive developed indigenously has been fully evaluated in lithium grease prepared with HCO. The additive has also been tested in lithium greases prepared with different base oils and the results are discussed. Lithium complex grease prepared using HCO and the additive has been tested fully. Its properties are compared with lithium complex greases prepared with 12 HSA and the commercial additives.

Introduction:

NLGI Annual Production Survey 2013 indicates that over 77 % of the total grease produced in the world is based on Lithium soap. Out of this around 19% is lithium complex grease. As per the survey, Lithium Greases having dropping point above 210°C are considered as complex greases in the NLGI Production Survey. In India around 90% of the total grease produced is lithium base and out of this around 5-7% is Lithium complex grease.[1] Lithium Complex Greases are popular for high temperature applications especially in Steel Plants where the operating conditions are most severe. For wide temperature applications, lithium complex greases are also prepared using synthetic oils such as PAO, OSP etc. Traditionally, lithium complex greases are prepared using various complexing agents such as boric acid and dibasic acids. Among the dibasic acids, sebacic acids and azelaic acids are most popular. Lithium complex greases prepared using sebacic acid and azelaic acid in synthetic hydrocarbon have similar physical properties.[2] The cost of these acids keep on varying and plays a role in the selection for use as a complexing agent.

These complexing agents are introduced into the grease in the initial stage of saponification. The use of these complexing agents increases the percentage of lithium hydroxide and there by increases the cost of the product. The grease manufacturing process for these greases is generally an open kettle process and is tedious, long and not very flexible.

It was first observed that Lithium complex greases having high dropping points, good extreme properties and very satisfactory water resistance properties can be prepared by employing borate esters-amine complexes in lithium hydroxy fatty acid soap thickened greases. It appears on the basis of IR and other evidence that a stable co-ordinated compound is formed by electron sharing between the boron atom of the borate ester compound and hydroxyl group of the hydroxy fatty acid soap, which accounts for the difference in the effect of the borate ester compounds in hydroxy fatty acid soap thickened greases and conventional fatty acid soap thickened greases.[3]

The advent of Boron Esters as complexing agents has made the lithium complex grease making process very simple. The presence of boron esters is not required in the cooking stage. It is added at the end of the manufacturing stage before homogenization/milling like other performance additives. Lithium complex greases produced by adding boron esters as complexing agents have shorter batch cycle times versus greases of conventional manufacture which results in energy savings & improved production efficiency.[4]

The boron esters employed to raise the dropping point of lithium greases are compounds of alkyl or aryl borates or aliphatic amines to form borate ester adducts or complexes. The borate esters added to lithium base greases form lithium borates which change the dropping point of lithium base greases. The change rate in dropping point varies depending upon the type of lithium borate formed i.e. monolithium borate, dilithium borate or trilithium borate or mixture of these borates. It has been established that presence of dilithium borate increases the dropping point to a large extent.[5] The presence of lithium phosphate also plays a role in boosting the dropping point.

The commercially available boron esters from various additive manufacturers are recommended in Lithium base greases made from 12 HSA. Although the lithium base greases prepared with 12 HSA are converted to lithium complex greases with high dropping point by addition of borate esters, the lithium complex greases so formed have poor mechanical stability as compared to complex greases prepared using dibasic acids.

It is also known that borate esters possess friction reducing, antiwear and antioxidant characteristics when blended in lubricating oils. X-ray photo electron spectroscopy and X-ray diffraction reveal that borate esters can be adsorbed on the rubbing surface and some of the adsorbed borate film degrades and forms boron nitride which is responsible to reduce the friction.[6] It has been observed that Lithium complex greases prepared from 12 HSA are slightly transparent and darker in color and have poor mechanical stability. The grease preparation is definitely easier and less time consuming as compared to preparing Lithium complex grease using dibasic acids or boric acid as complexing agent. In addition, there is flexibility and reliability regarding getting the required high dropping point.

However, the mechanical stability in terms of difference between 60 strokes and 100 k strokes penetration and roll stability is inferior in lithium complex grease prepared from lithium grease from 12 HSA as compared to lithium grease with HCO. The cost of the final grease also goes up as 12 HSA is costlier than HCO. Further the batch cycle time of lithium 12 HSA grease is higher than the same grease with HCO as in the latter case saponification is carried out in pressure vessel.

A special process has been developed to convert conventional lithium base grease with HCO into lithium complex grease with the addition of borate ester. The same additives which are used as dropping point boosters based on Borate ester chemistry are used.

Experimental work, results & discussions-

Dropping point boosters additives based on borate ester chemistry are available in the market from reputed additive manufacturers. All these additive manufacturers advise to use their additive in lithium base grease prepared with 12 HSA. The dosage recommended by most of the additive manufacturers range from 1 to 3 % of the total charge and the additives are recommended to be added at temperatures below 90° C. The regular use of these additives in Lithium greases with 12 HSA in recommended dosages have confirmed that the use of these additives raises the dropping point to more than 260°C there by converting normal lithium base grease into lithium complex grease. However, the same boost in the dropping point is not observed if these additives are added in lithium base grease prepared from HCO.

Different dropping point boosters available in the market were collected. (Additives A, B,C,D & E).As per the Technical Data Sheet of these boron esters, the chemical structure of these additives were different from each other.

Lithium complex greases were prepared using Lithium base greases with HCO using the newly developed process. The developed process was successful in raising the dropping point of all lithium base greases prepared from HCO with all the different boron esters. Table 1 shows the results of dropping point of lithium base greases made with HCO, paraffinic oil and with different borate ester additives. The additive dosages in all the samples were same. The efficiency in boosting the dropping point was however different. But all the samples gave dropping points more than 260 °C which is generally the requirement in the specification of Lithium complex grease.

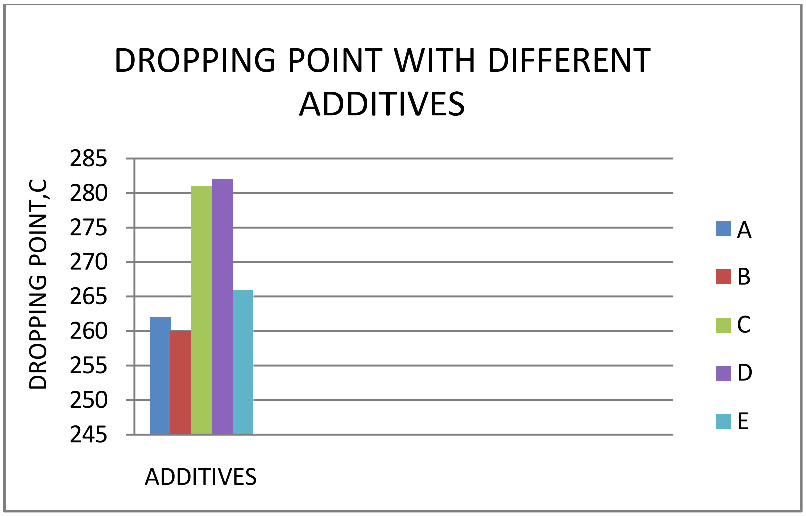
TABLE 1

Dropping Point of Lithium Complex Greases with HCO & Paraffinic oil

Sr. No.	Boron Esters @3% dosage	Dropping point °C ASTM D 2265
1	A	262
2	B	260
3	C	281
4	D	282
5	E	266

The drooping point of Lithium Complex greases using boron esters A, B, C, D &E are depicted on bar chart Fig.1 below.

FIG.1



The additives C&D give highest boost in dropping point.

It was observed that the developed process of preparing lithium complex grease from the lithium base grease with HCO has been successful and gives dropping point above 260°C with all the boron esters tested. The boost in dropping point varies depending upon the type of boron ester used. The dosages of boron esters can be further optimized there by further reducing the cost of the lithium complex grease.

As the developed process was found to be successful in paraffinic oil, the same was tried out in different types of base oils to check the efficacy of the process. The boron esters C &D which have given maximum boost in dropping point were selected for this study.

Following oils were selected.

Paraffinic

Naphthenic

Poly Alfa Olefin (PAO)

Oil Soluble Polyglycol (OSP)

Since the majority of Automotive and Industrial greases are made with base oil viscosity of VG-220, the same viscosity grade was used for making these greases.

The properties of the oils used are given in Table 2

TABLE 2

Characteristics	Test Method	PAO	OSP	Naphthenic	Paraffinic
Appearance	Visual	Clear, Bright	Clear, Bright	Clear, Bright	Clear, Bright
Density	D-7042	0.8332	0.9532	0.9101	0.8878
Kin. Viscosity @ 40°C,cSt @100°C,cSt VI	D-7042	 232.5 26.77 149	 236.5 32.2 180	 217.4 13.8 33	 201 17.6 94
Flash Point, °C	D-92	222	216	240	265
Pour Point, °C	D-97	-33	-27	-9	-3

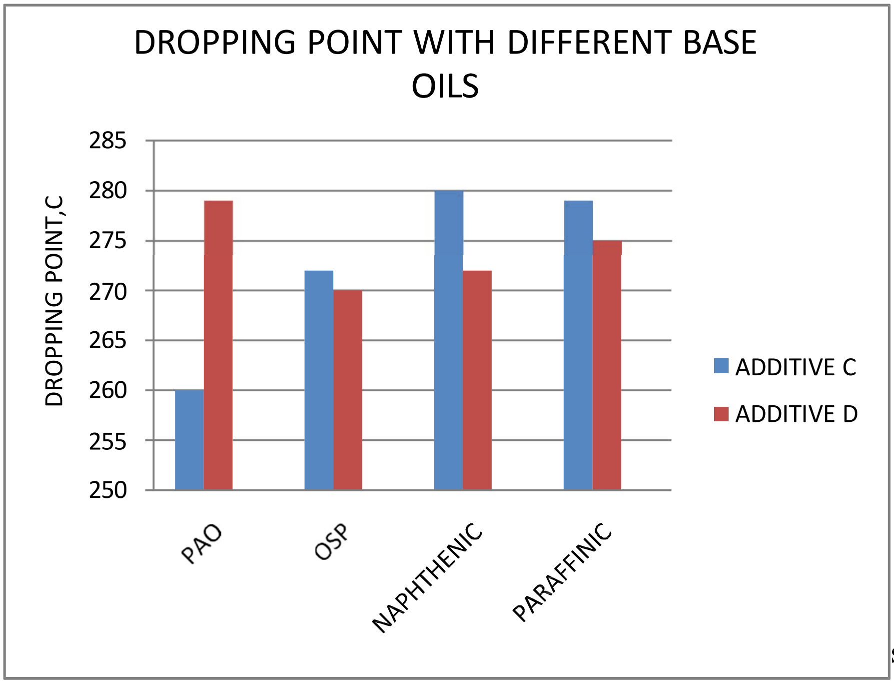
Only two of the above boron esters C & D which had given very good results were selected for further study. Lithium complex greases were prepared using HCO and these base oils in VG-220 viscosity grade and the above two boron esters. The Table 3 gives the dropping point results of these greases.

TABLE 3

Tests	Test Method ASTM	PAO		OSP		Naphthenic		Paraffinic	
Additives		C	D	C	D	C	D	C	D
Dropping point,° C	D-2265	262	279	272	270	280	272	279	275

The dropping point results are shown in bar chart .Fig.-2

FIG.2



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It is observed that both the additives C &D boost the dropping point of lithium base greases prepared with HCO in different base oils such as PAO, OSP, Naphthenic & Paraffinic oils. However, the increase in dropping point is different with different base oils.

Although the boost in dropping point of lithium complex grease by addition of boron ester is not fully understood, there are different theories proposed. G.S. Bright had carried out systematic studies on the relationship of solubility parameters of various oils and the properties of lithium soap greases. He concluded that there appears to be straight line relationship between solubility parameters of the oils and dropping point of lithium 12 hydroxy stearate greases made from them. The higher the solubility parameter, the lower the dropping point.[7] So the different solubility parameters of different oils might be responsible for different boost in dropping points of lithium greases prepared from these oils with addition of boron esters.

Further, one of the additives (C) was used to prepare lithium complex grease (Grease CX) with developed process from lithium base grease prepared with HCO. This grease was evaluated for all the major tests. The properties of this grease were compared with the properties of lithium complex grease (Grease CY) prepared with the same oil and same boron ester but with lithium base grease prepared with 12 HSA. One more commercial batch of lithium complex grease (Grease DY) prepared from lithium base grease with 12 HSA using boron ester D was also taken for comparison. The base oil used in all the three greases is same (VG-100 Paraffinic oil of

Group 1) All the three greases were fortified with same EP and AW additives in the same dosages.

Grease CX- Lithium Complex Grease prepared from lithium grease

with HCO & borate ester C in paraffinic oil of

VG-100 with EP & AW additives.

Grease CY-Lithium complex grease prepared from lithium base

Grease with 12 HSA & borate ester C in paraffinic oil

of VG-100 with EP& AW additives.

Grease DY- Lithium complex grease prepared from lithium base

Grease with 12 HSA & borate ester D in paraffinic

Oil of VG-100 with EP& AW additives.

The properties of these three greases were compared and the test data is given in Table 4.

TABLE 4

Tests	Test Method ASTM	Lithium grease with HCO Boron ester C Grease CX	Lithium grease with 12 HSA Boron ester C, Grease CY	Lithium grease with12 HSA Boron ester D, Grease DY
Appearance	Visual	Smooth, homogeneous	Smooth, homogeneous	Smooth, homogeneous
Color	Visual	Light Brown	Light Brown	Light Brown
NLGI Grade	D-217	2	2	2
Penetration, Worked,X60 Workedx100000 Difference	D-217	 268 286 +18	 268 296 +28	 286 322 +36
Dropping point, °C	D-2265	276	272	268
Roll stability, 16 hrs. RT, %change	D-1831	11.4	17.85	19.35
Water washout, % wt	D-1264	1.6	2.5	3.2
Water spray off	D-4049	6.0	4.7	4.5

Copper corrosion, rating	D-4048	1b	1b	1b
Weld Load, Kgs	D-2596	250	250	250
Wear scar dia, mm	D-2266	0.45	0.48	0.57
Fretting Wear, wt loss, mgm	D-4170	1.5	2.6	1.4
Oil separation, %wt	D-1742	0.8	0.9	0.9
Heat Stability Test % oil separated	D-6184	2.7	2.0	2.5
WB Life Performance Test leakage, Gms.	D-4290	8.0	6.0	9.0
Oxidation stability, drop in pressure, psi	D-942	2.0	3.0	4.0

Mechanical Stability- All the three greases were subjected to 100k strokes. The mechanical stability was determined by checking the difference in 60 strokes and 100k strokes penetration units. The difference in Grease CX was found to be +18 against +26 and +36 in Greases CY & DY. Thus the Grease CX has better mechanical stability as compared to Greases CY &DY. This was further confirmed by Roll Stability Test carried out for 16 hrs. at room temperature (26 °C). The difference in penetration before and after the test was found to be 11.4 % for Grease CX against 17.8% & 19.3% for Greases CY & DY. Thus the Grease CX has better mechanical stability than the Greases CY &DY.

High Temperature properties-The Lithium complex greases are recommended for Automotive and Industrial applications for high temperature applications. Generally, the maximum recommended high temperature is around 160 °C. The wheel bearing life performance test was carried out on all the three samples. The test temperature is 160°C. All the three greases have given the leakage within 10 gms. which is the limit specified by GC specification under ASTM D-4290. The dropping points of all the three greases are above 260°C.

All the other properties such as EP, AW, corrosion inhibition and oxidation resistance properties of the three greases are comparable.

It is observed that Grease CX has better mechanical stability than Grease CY and Grease DY. The roll stability results also confirm the superior mechanical stability of Grease CX compared to Grease CY & Grease DY.

This was further confirmed by preparing few more batches of lithium complex greases using lithium base greases prepared from HCO. The other properties like water resistance, corrosion inhibition, EP and anti wear properties are comparable or superior.

Conclusions-

A process has been developed to manufacture Lithium complex greases using the commercial additives based on borate esters and Lithium greases prepared with HCO.
The developed process has given better lithium complex greases and is cost effective as compared to lithium complex greases prepared with 12 HSA. The batch process time is also reduced by around 20% These greases have better mechanical stability as demonstrated by the prolonged work penetration test and roll stability test. In both the tests the grease with HCO has given better mechanical stability the than those prepared with 12 HSA with the same borate esters.
The developed process also works in other types of base oils in raising the dropping point of lithium base greases prepared with HCO.
With this process, while manufacturing normal MP grease, if required a part of the grease can be converted to lithium complex grease without any major hassles.

Acknowledgement-

The authors wish to thank the management of Standard Greases & Specilities Pvt. Ltd. for their support and permission to present this paper in NLGI-IC meeting at Chennai.

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Wheel Hub Bearing Application (Grease A)

S.K. Haldar[1], Abhinav Jogi[2], Prasad Warwandkar[3]
[1]Indian Oil Corporation Limited,
[2]Indian Oil Corporation Limited Indore
[3]VE Commercial Vehicles

ABSTRACT

Lubricating greases are semi-fluid or solid lubricants consisting of a thickener in a liquid lubricant fortified with various additives. One very popular lubricating grease type is the Complex grease which contains a second organic acid also known as the complexing agent, the type of which depends upon the end product desired properties.

This paper outlines the performance of **Grease A**, which is NLGI-3, Lithium-Complex grease, developed specifically for wheel bearing applications of medium to heavy commercial vehicles segment for a life of more than 100 thousand kilometres (>100K Kms). We will illustrate how our **Grease A** possesses the potential to outperform conventional Lithium, Calcium & Calcium-complex greases in terms of life and cost effectiveness.

Commercial vehicles OEM's have been traditionally using Lithium soap greases with a re-greasing period of 36K Kms. This application specifically imposes fatigue stress on the grease. Varying weather/ambient conditions across the country, the intense nature of loads on wheel hubs in field operations and needless to mention, the improper driving conditions together act as an abuse on the grease. Therefore, generally, single soap greases have a limited potential of commercially clocking a modest 36K Kms life. Considering today's competitive scenario, a need was felt to develop a longer life and cost effective high performance grease for wheel bearing application keeping in mind service optimization.

This need to increase the re-greasing period economically in commercial vehicle segment is the need of the hour and here our Lithium-Complex based **Grease A** has given very good results. **Grease A** has primarily a much more robust structure which gives it higher mechanical shear stability, a higher drop point, better water washout characteristics & an overall superior package as compared to conventional alternates.

We have conducted field trials of our grease till more than 100K Kms and based on test results & good condition of the grease, usage can be extended to even up-to 120K Kms. Besides this, 80K Kms & 100K Kms are also servicing intervals for major OEM's which give the added benefit of synchronized re-greasing periods. Based on our field trials & results, **Grease A** has the potential to be today's single solution for wheel bearing application.

This special grease study illustrates the challenges that exist in wheel bearing application considering long life expectations along with various external imposed conditions and the performance of **Grease A**. In particular, factors that can influence performance, such as speed, driving conditions, maintenance practices and operating temperatures, are dealt with in some detail.

This paper evaluates the performance & cost effectiveness of **Grease A** in comparison to conventional greases for commercial vehicles wheel bearing application for a useful life of above 100K kilometres along with the limitations and future applications.

1.0 INTRODUCTION
1.1 OEM Considerations – Indian Scenario & Global Impact

The Indian Automotive Industry has come a long way since independence and has transformed from a locally focussed industry into one of the fastest growing automotive markets in the world. India, now boasts to have the 7th largest automotive industry in the world with a dominating presence of most of the Global leading players. In fact, liberalisation policies and concurrent induction of foreign competition has changed the market dynamics in the auto industry over the last few decades.
The following table illustrates the importance of the Automotive Industry to the exchequer, investments of global players & our Global Ratings in the different sectors of this industry.

Parameters	**Value**
Importance to Economy	
Turnover	73 Billion US Dollars
Share in National GDP	6%
Share in Manufacturing GDP	22%
Share in ED Collection	21%
Employment	More than 13.1 Million people
FDI Inflows	6.96 Billion US Dollars*
Global Ranking	
Three Wheelers	1st
Two Wheelers	3rd
Commercial Vehicles	5th
Passenger Cars	7th

*For the period April 2000 – June 2012
Source: Report of the Working Group on Automotive Sector for the 12th Five Year Plan;

Table-1: Indian Automotive Industry & Global Impact

1.2 Commercial Vehicle Segment

In the Commercial Vehicle (CV) segment, thrust on product development by domestic players and the entry of foreign players has resulted in the introduction of advanced products into the market. While this is fuelling further market competition, it is also leading to a structural shift, with demand increasing for higher tonnage trucks, indicating towards a maturing product mix.
Coming to the lubrication aspect with respect to Commercial Vehicle segment, a paradigm shift has been observed across all the OEM's. Major players like Tata Motors, Ashok Leyland, VE Commercial Vehicles, Mahindra &Mahindra etc., over a period of time have shifted from regular lubricants to high performance lubricants promising longer life and durability at the same time. This process has been further accelerated by the technological advancements, systemic approach & need to meet global demands of foreign associates and export businesses.

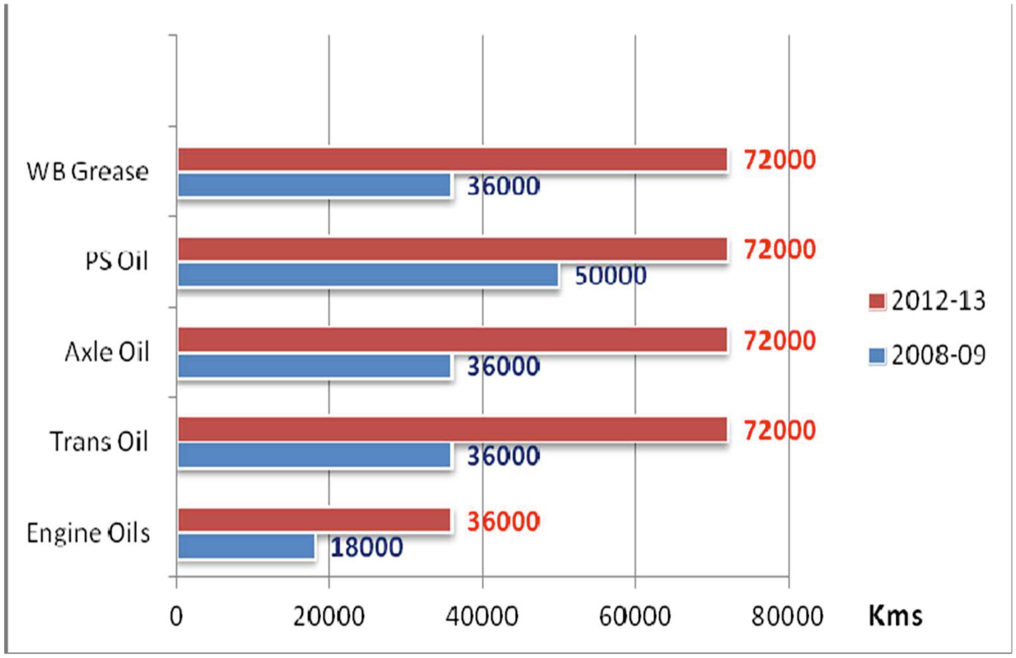

Figure-1: Drain Periods shift in CV Segment 2009 v/s 2012

With a wide range of trucks in their kitty in terms of payload (especially launch of higher tonnage trucks with the advent of indigenously manufactured High Power Diesel Engines > 250 HP), OEM's face diverse expectations from the field in terms of service intervals. To meet these expectations, there is a need to conduct durability trials of new generation lubricants and establish new performance standards for effectively meeting such expectations and creating new benchmarks within the industry.
Our work is a direct result of close association in terms of technical inputs, meetings & trials with a major OEM which has been constantly growing in terms of market share & brand image over the last few years.

1.3 Grease A – How it Started

We have seen in Section 1.2 the journey of major OEM's till 2012-13 in terms of drain intervals. The constant driving factor has always been to stay ahead of competition in terms of Fuel Efficiency & Performance. This is majorly met by having more fuel efficient engines & drive-trains. Further, use of advance lubricants can contribute to as large as 6.5% improvement in fuel economy across the power-train.

We started closely working with our customer and understood their requirements which had the following key points:

- Introduction of tailor made Long Life & Fuel Efficient grades with drain periods almost double of current values
- Durability of the systems and components & compatibility with seals & other materials.
- Grades to have higher life for HD segment trucks as compared to LCV/MCV's and optimization of service intervals.
- Marginal increase in costs.

Figures 2 & 3 illustrate the planned roadmap for LCV/MCV & HD segments:

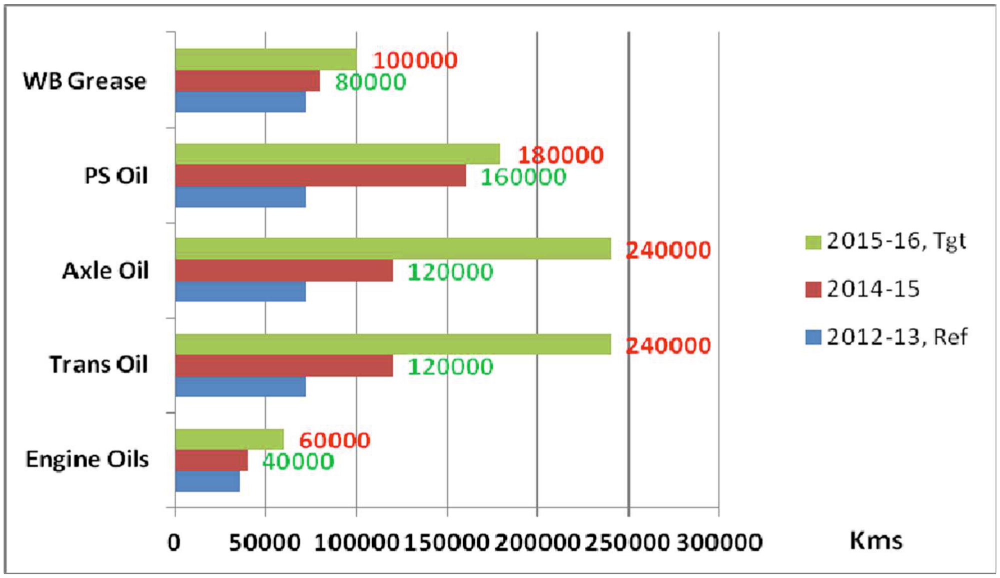

Figure-2: Current v/s Future Roadmap for LCV Segment Vehicles

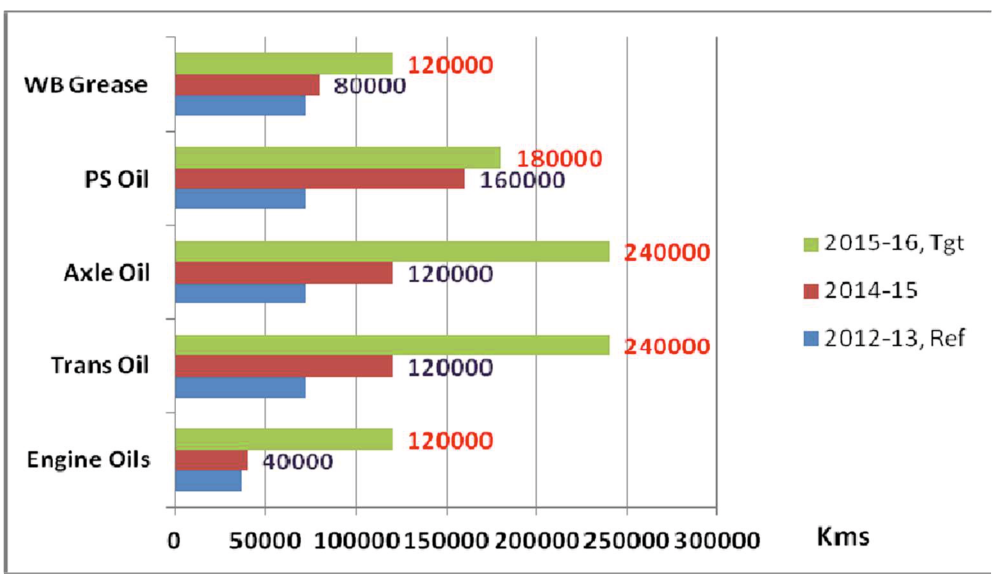

Figure-3: Current v/s Future Roadmap for HD Segment Vehicles

One of the main lubricants which needed detailed field testing was the wheel bearing grease application. Earlier, the customer was using NLGI-3 Lithium soap grease for a life of 36000 Kms. We submitted to the customer detailed specifications for planning field trials of our new Lithium Complex grease, **Grease A**, which was capable of giving very good performance and long life.
Before going to the trials sections, let us understand the Wheel Hub Bearing application and main challenges.

2.0 WHEEL HUB BEARING APPLICATION & CHALLENGES

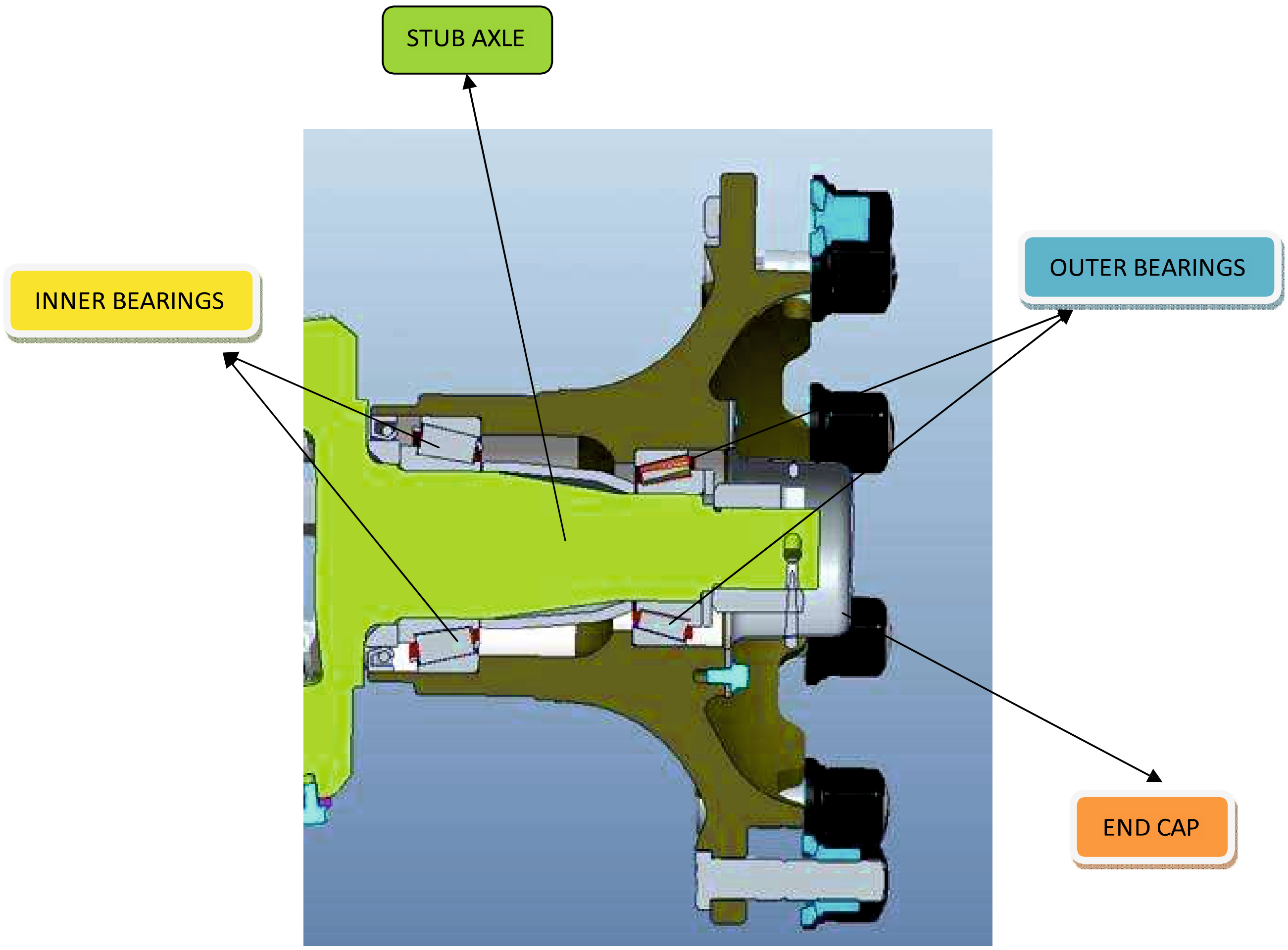

Figure 4: Rear Wheel Hub Schematic – Cross Sectional View

The Wheel bearing assembly can be considered as the main load bearing unit of any commercial vehicle and therefore one can imagine the loads on the wheel bearing grease. Generally wheel bearing greases are exposed to fatigue and shock loads (sudden braking) along with a hostile environment and a long life is only possible with a robust structure along with use of superior base oil fortified with high performance additives.

In today's tough Indian market scenario, in the name of use, most commercial vehicles are practically abused. In Indian conditions, following practical conditions are also required to be considered:

- **Excessive Loading or Overloading:** Excessive loading is a very common phenomenon in this part of Asia and can be easily witnessed anywhere pan-India. Apart from other problems, excessive loading or overloading can cause the grease in between the rollers to come out thereby causing the rollers to run hotter. This localised temperature rise can cause the grease to overheat and melt thereby causing failures.

- **Improper Driving Habits:** A very common practice is excessive speeding and sudden braking. This, especially when overloaded, can cause extreme shock loading on the wheel bearing grease which is anyways under fatigue stress & therefore early deterioration of the grease.

- **Delay in maintenance practices:** Most fleet owners in the country operate across the country and there is a pressing need to deliver consignments on or before time. Heavy competition forces fleet owners to prioritize their jobs at hand over timely service.

3.0 WHY LITHIUM COMPLEX?

Today Lithium soap greases are known for many improved properties compared to the other soap greases. For example, they exhibit better high temperature properties as compared to calcium soap greases, better water resistance properties compared to sodium soap greases & very good resistance to shearing and good pumping characteristics.

Lithium complex greases possess many of the properties of simple lithium soap greases and also have higher dropping points, allowing the greases to be used at higher temperatures. Mechanical stability, also known as shear stability, is the ability of grease to maintain consistency when subjected to mechanical shear forces. Simple lithium greases have good resistance to breakdown due to shear, and lithium complex greases also exhibit good resistance to shear.

The water resistance of simple lithium and lithium complex greases is related to the solubility of the thickener. Lithium hydroxide has limited solubility in water (about 10 percent), and the thickeners based on it also have limited solubility. This provides good resistance to both washing by water and the absorption of water. Although other thickener types (calcium, barium) have better inherent water resistance compared to lithium and lithium complex thickeners, those products have negative aspects that make them less desirable for many applications. In addition, the water resistance properties of simple lithium and lithium complex greases can be enhanced by the addition of polymer additives in small concentrations.

The oil separation properties of a grease relate to both the product's lubrication ability and storage stability. The grease must release enough oil in the contact zone of the application (bearings, gears), while not releasing so much oil during storage to cause the product to become unusable. If the oil separates excessively during storage, the grease may not be able to be remixed and used.

4.0 FIELD TRIALS

Field Trials of **Grease-A** were carried out with our OEM on four vehicles from the commercial vehicle segment. All these four vehicles have a similar wheel bearing design as shown in the earlier section. The vehicles were run for a period of 4 – 6 months and were subjected to different types and sizes of payloads across varying ambient conditions.

Based on the availability of vehicles, the trial was done in two stages as under:

Stage – 1 (On all the four vehicles): 0 to 80,000 Kms Stage – 2 (On one vehicle): 80,000 Kms to

1,00,000 Kms The Trial Protocol followed is as under:

- Identification & tagging of field vehicle due for scheduled maintenance.
- Removal of old grease from wheel hubs (Front Left & Right, Rear Left & Right) & bearings within followed by thorough cleaning.
- Greasing of all the four hubs per vehicle with **Grease – A**.
- Physical examination of the wheel hubs for signs of any oil separation/leakage after every 10,000 Kms.
- Feedback from operator/driver for any un-desirable performance issue.
- Opening of the Wheel Hubs at the end of 80,000 Kms

i.e. Stage – 1 when the vehicles return for scheduled maintenance.

- Visual examination of the grease and collection of sample from all the four hubs for testing.
- Stage-2 for one identified vehicle (Vehicle – 3) with same Grease – A till 1, 00,000 Kms keeping in mind point no. 4 & 5.

- Opening of the wheel hubs after 1, 00,000 Kms for this vehicle with visual examination & sample collection for testing.

Summary of the running of our trial vehicles is shown in as under:

Vehicle Name	Registration No.	**Starting Reading (Kms)**	**Re- Greasing Reading (Kms)**	**Total Running (Kms)**
Vehicle – 1	MP09 GE- 7283	12899	92960	80061
Vehicle – 2	MP09 GE- 7282	10231	90345	80114
Vehicle – 3	MP09 GE- 7357	21100	121699	100599

Vehicle – 4	MP09 GE- 7285	18433	75406	57021

Table – 2: Stages 1 & 2 Vehicle running details

Note: Vehicle 4 had to be taken out from the trial due to major maintenance work in the engine. The same could not complete the trial.

Excerpts from the test reports of **Grease A** after Stage-1 of the trial along with snapshots of hubs/bearings are illustrated as under:

<u>VEHICLE – 1:</u> Hub opened after 80061 Kms.

	Front RHS HUB	Front LHS HUB	Rear RHS HUB	Rear LHS Hub
Appearance	Homogenous	Homogenous	Homogenous	Homogenous
Dropping Point	260	232	225	228
tration @ 25°C				
Worked	239	237	247	241
Metal Analysis – ICAP				
Fe	377	387	540	1727
Zn	1377	881	1390	1297
Cr	3	2	4	8
Cu	13	108	9	25
Ni	< 1	2	< 1	2
Si	0	0	0	0

Table – 3: From Front & Rear Right Hand Side & Left Hand Side Hubs of Vehicle – 1.

Figure Set – 5: Front Right Hand Side Wheel Bearings and Whee1 Hub of Vehicle – 1.

Figure Set – 6: Front Left Hand Side Wheel Bearings & Wheel Hub of Vehicle – 1.

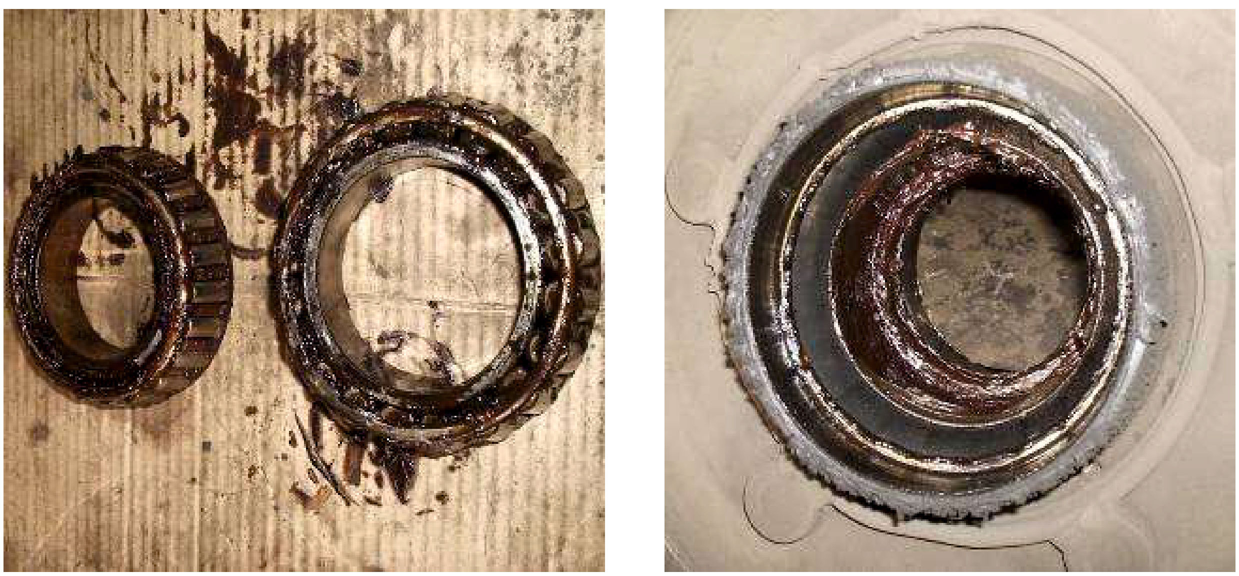

Figure Set – 7: Rear Right Hand Side Wheel Bearings & Wheel Hub of Vehicle – 1.

 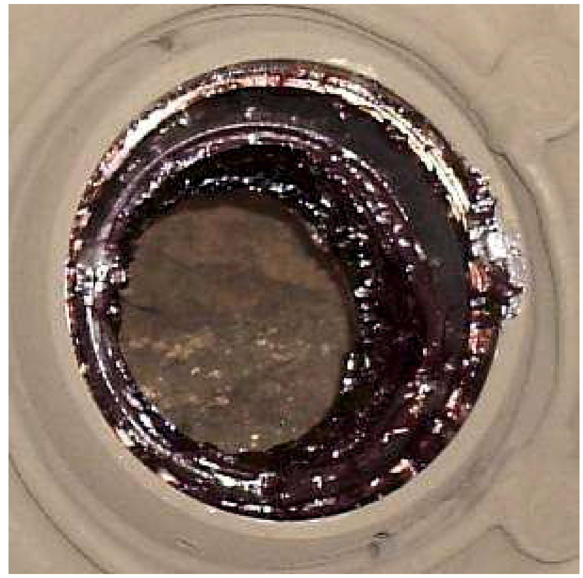

Figure Set – 8: Rear Left Hand Side Wheel Bearings & Wheel Hub of Vehicle – 1.

VEHICLE – 2: Hub opened after 80114 Kms.

	Front RHS HUB	Front LHS HUB	Rear RHS HUB	Rear LHS Hub
Appearance	Homogenous	Homogenous	Homogenous	Homogeneous
Dropping Point	267	274	257	260
tration @ 25°C				
Worked	235	241	259	240
Metal Analysis – ICAP				
Fe	85	292	309	280
Zn	893	1184	810	799
Cr	3	2	1	3
Cu	0	94	0	5
Ni	1	2	2	1
Si	0	0	0	0

Table – 4: From Front & Rear Right Hand Side & Left Hand Side Hubs of Vehicle – 2.

Figure Set – 9: Front Right Hand Side Wheel Bearings & Wheel Hub of Vehicle – 2.

Figure Set – 10: Front Left Hand Side Wheel Bearings & Wheel Hub of Vehicle – 2.


Figure Set – 11: Rear Right Hand Side Wheel Bearings & Wheel Hub of Vehicle – 2.

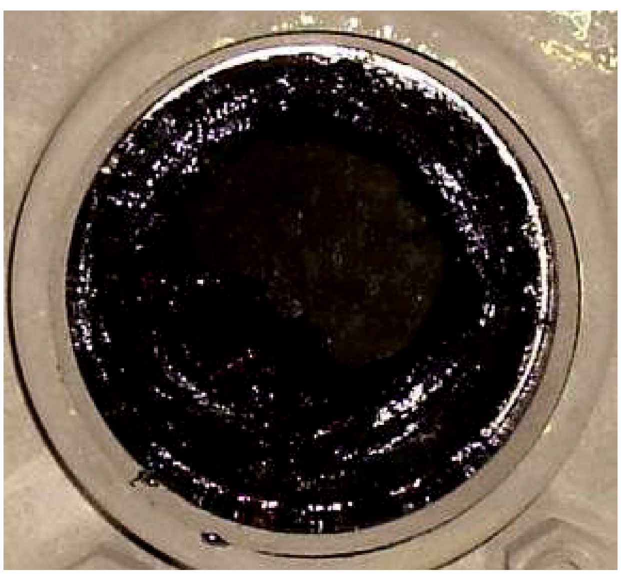


Figure Set – 12: Rear Left Hand Side Wheel Bearings & Wheel Hub of Vehicle – 2.

VEHICLE – 3: Hub opened after 100599 Kms as per Stage-2 trial protocol.

For this vehicle, we have illustrated the wheel hubs and bearings after cleaning the grease completely. It is noteworthy here that the hub & the bearings are in very good condition.

	Front RHS HUB	**Front LHS HUB**	**Rear RHS HUB**	**Rear LHS Hub**
Appearance	Homogenous	Homogenous	Homogenous	Homogenous
Dropping Point	240	258	227	238
Worked Pen @ 25 Deg Cel.	250	255	260	259
Metal Analysis				
Fe	1285	1050	1300	1330
Zn	1447	1326	1224	1180
Cr	11	13	38	9
Cu	11	8	10	12
Ni	2	3	10	3
Si	0	0	0	0

Table – 5: From Front & Rear Right Hand Side & Left Hand Side Hubs

Figure Set – 13: Front Right Hand Side Wheel Bearings & Wheel Hub – Post removal of the grease.


Figure Set – 14: Front Left Hand Side Wheel Bearings & Wheel Hub – Post removal of the grease.


Figure Set – 15: Rear Right Hand Side Wheel Bearings & Wheel Hub – Post removal of the grease.

Figure Set – 16: Rear Right Hand Side Wheel Bearings & Wheel Hub – Post removal of the grease.

5.0 RESULTS & COST EFFECTIVENESS

5.1 Results:

The field trial reports and physical conditions of the bearings and wheel hubs as seen in Section 4.0 have been analysed as under:

- In three of the four trial vehicles, **Grease A** gave satisfactory performance till at least 80,000 Kms. The test reports at 80,000 Kms show good condition of the grease

- In one trial Vehicle – 3, **Grease A** gave satisfactory performance till at least 1, 00,000 Kms. The condition of **Grease A** after opening the hub was good.
- Based on the condition of Grease A in the test report from Vehicle – 3, **Grease A** can be used further till 120K Kms.

- Also, since **Grease A** is NLGI 3 and since globally for Commercial Vehicle applications NLGI 2 & 3 consistency greases are both used, we have the added buffer for **Grease A** moving from NLGI 3 to NLGI 2 with use and still giving good performance in the application.

5.2 Bio-Degradability:

The additives used in **Grease A** are environmental friendly unlike other additive dosage. This grease is 94% bio-degradable. These are not only readily bio-degradable but also non-hazardous in water.

6.0 CONCLUSION

The trial results presented in the study show that **Grease A**, a NLGI 3 Lithium-Complex grease, is capable to giving good performance for an extended life of 120K Kms. **Grease A** can be effectively adopted for Wheel Hub Bearing application for all types of Commercial Vehicle applications especially when a diverse service schedule is desired.