DEVELOPMENT OF POLYUREA GREASE FOR HIGH TEMPERATURE, HIGH LOAD BEARING APPLICATION

by

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Polyurea greases are among the most important advances in grease technology. These are non-soap greases where thickener moieties do not contain any metallic elements rendering the grease ashless.The first reported polyurea grease was made with aryl-substituted ureas during 1954. Attempt at that time was made to develop a fibrous polyurea grease primarily as a replacement for the barium greases which have disposal problems related to barium toxicity.In Japan, urea greases were re-evaluated in 1980s. Since then , urea greases gained importance in steel plants,automotive wheel bearings , constant velocity joints, electrical instrumentation and auxiliary equipment bearings.

ABSTRACT

- The polyurea greases are among the most important advances in grease technology.They are outstanding lubricants for ball and roller bearings operating under relatively high temperature and speeds. This paper outlines the development and evaluation of an aryl-subsituted polyurea grease suitable for use in continuous casting segments of iron and steel making plants.

THEORETICAL CONSIDERATION

- **In continuous casting, molten steel refined by the blast furnace and the converter is solidified into an intermediate product called the slab or bloom. It is supplied to the rolling mill. The producivity of the continuous caster (CC) therefore is very important as it often controls the production capacity of the entire steel works. The CC is composed of the unit which is called “segment” in which a number of guide rolls are arranged as upper and lower pairs.**

Bearing life of the guide roll is the main factor in determining the exchange cycle. In addition, the purchase cost of the bearings for CC accounts for about 40% of the bearing purchase cost in the entire Steelworks. Therefore extension of bearing life is of the topmost priority. Typically these bearings operate at low speeds (< 10 rpm) and high loads (C / p > 7) and high temperatures (80 – 300 deg C , i.e., under boundary regime.

In general, thermostable grease based on mineral oil is used for the lubrication of CC bearings. Recently polyurea greases are being used for improved protection of metal surface. The authors' laboratory has made an attempt to develop such polyurea grease. The developed polyurea grease is a sealing grease with high capability of keeping water and abrasive foreign particles out of contact with excellent oxidation stability, thus maintaining the expected technical life of the bearings.

- The combination of high surface affinity (inherent to the molecular structure of the thickener-matrix) with well-balanced additivation and thick oil viscosity offers a lubricant designed for long time lubrication and high performance in thermally stressed operating environment.

BEARING LIFE

- Bearing life is defined as the length of time, or the number of revolutions, until a fatigue spall of a specific size develops. The spall size , regardless of the size of the bearing, is defined by an area of 0.01 inch square (6 mm square).This life depends on many different factors such as loading, speed , lubrication, fitting , setting, operating temperature, contamination, maintenance , plus many other environmental factors.

- L10 life is the life that 90 per cent of a group of apparently identical bearings will complete or exceed before the area of spalling reaches the defined 0.01 inch square size criterion.
- L10 = (C/P) 10/3 x (B / n) x a
- L10 in hours
- C= radial rating of the bearing in N
- P= dynamic equivalent radial load applied on the bearing in N

B= factor dependent on the method

- A= life adjustment factor ; a=1 when environmental conditions are not considered
- N= rotational speed in rev/min
- Doubling load reduces life to one tenth
- Doubling speed reduces life by one half

PROCESSING

- The grease is manufactured by combining oil solutions of amines and toluene diisocyanate in a grease kettle. The grease is heated to ensure completeness of reaction, additional oil is added for consistency adjustment.Additives are added to the grease mixture prior to milling. The finished grease is subjected to physico-chemical evaluation.

Temperature during addition of amines to toluene diisocyanate - 60 to 70 deg C

- Max processing temperature 170 deg C
- Aliquot of mixing mass was withdrawn at different intervals during progress of reaction after the complete addition of amines and di isocyanate and subjected to FTIR ananlysis for observation of the diisocyanate peak at 2150 – 2250 cm inverse

RESULTS

- FTIR STUDIES
- A typical infrared spectrum shows peaks at frequencies 3300, 1640 and 1560 cm inverse are the principal absorbance characteristics of polyurea greases and can be used to identify grease of this type.

It is observed that after 25 minutes of processing of the reaction mixture after complete addition of reacting ingredients , the reaction is completed as indicated by the gradual disappearance of the peak at 2150 – 2250 cm inverse (diisocyanate peak)

TGA

- The thermogravimetric study indicates that the grease is thermally stable upto 280 deg C and decomposition starts at 290 deg C. It is also observed that the grease leaves nearly no residue after 500 deg C (base grease is ashless)

- Differential scanning calorimetric study indicates that the first transition occurs after 270 deg C which indicates good thermal stability.

- Frictional co-efficient as measured by SRV (3 ae mode) shows a value much below 0.10

- SEM study of the structure of the thickener indicates that polyurea thickeners are closely packed clusters of several particulates of average size 0.5 micrometer or below which renders a compact structure.

Neutralisation of excess reactants

- It is desired to put some coupling agents after processing of the grease to neutralize the unreacted TDI , if any . Moreover coupler plays certain role to enhance the intermolecular hydrogen bond strength of the thickener clusters through cross linking mechanism.

High temperature properties

- The high dropping point , higher than 260 deg C (ASTM D 566) , characteristic of the thickener, would be a performance advantage in high temperature environments

- For long periods at temperature range between 90 to 150 deg C bearing performance / life can be best measured by ASTM D 3336 method
- Developed grease shows a value of 325 hours in comparison with the Lithium complex grease (with same base oil of viscosity 410 cSt at 40 deg C) life time of 220 hours.

OXIDATION STABILITY

- ASTM Bomb Oxidation (D942) gives a value of 2 psi at 100 deg C, 100hrs

RUST PROTECTION

- A number of organic and inorganic rust inhibitors has been found to be quite effective with the developed grease to pass rust test as per IP 220

WATER RESISTANCE

- Developed grease can prevent the water intrusion due to its high water resistance
- As per ASTM D 1264 (79 deg C , 1 hour) % water wash out value is 1.6

EP PROPERTIES

- An EP package has been used which promotes good low frictional properties (coefficient of friction 0.09)as per ASTM D 2266 and good 4 ball weld load (355 kgs) as per IP 239
- While checking the effect of solid EP agents , it is observed that graphite has better load bearing capability than MoS2

SEAL COMPATIBILITY

- There are a variety of seal materials and seals are designed to keep the grease in the bearing while keeping out extraneous materials and moisture.

OIL SEPARATION

- Oil separation of the developed grease is found to be 0.22 % as per ASTM D 1742

EFFECT OF CORROSION INHIBITOR ON DROPPING POINT

- Yellow metals are frequently used in machine elements.Due to their tendency to react with active sulphur-containing extreme pressure and anti wear additives, it is necessary to use yellow metal deactivators.
- It is observed that using of barium naphthalenesulphonate type CI , dropping point of the grease is severely affected. Drop point decreases to 210 deg C from its initial value of 262 deg C

- Reason cannot be ascertained with great reliability at this stage , but it seems that the thickener matrix gets disturbed either by breaking of gel structure or by some chemical antagonistic effect.
- The fact is corroborated by the oil separation test. Additivated grease shows oil separation value of 3.4 % as compared to initial value of 0.22%

SEM

- SEM study indicates compact structure.
- Closely packed clusters of several particulates of avg size 0.5 um or below

SHEAR STABILITY / ROLL STABILITY

- WP 60 = 312
- WP 100,000 = 340

- Shear stability and roll stability depends on the nature and strength of the thickener moiety and its binding strength with the oil.
- Polyurea grease structures are generally of three types – Fibrous , Spiral(ribbon) and Macaroni (pipe set)

ROLL STABILITY

ASTM D 1831 gives a value of 12 % change in roll stability (96 hrs at 82 deg C)

Effect of couplers

Coupling agent	WP 60	WP 10000	Dropping point deg C
EDA	328	348	260
Water	312	340	262

- Depending on molar ratio of ingredients temperature and time of processing the structure of the polyurea grease is determined. If the grease is processed at high temperature the possibility of getting macaroni structure is high.
- Roll stability and shear stability is determined by the structure – a good combination of fibrous and spiral is required for good roll as well as shear stability.

COMPATIBILITY

- Grease compatability is important when a switch is made from one type of grease to another.Excessive changes in consistency of the grease mixture can lead to improper lubrication. While mixing developed grease(at 50 deg C) with 10% level of aluminium complex or calcium base grease of same consistency softening occurs upto a value of 10 to 12 units .

- In case of lithium base and soda base grease hardening is observed (9 to15 units)

So it would be appropriate to purge out most of any residual grease when a different type is being started.

PUMPABILITY

- Good flow properties are essential for grease to be used in steel plant applications. Often the grease is dispensed through centralised dispensing system.
- The developed grease possesses good pumpability characteristics particularly at low shear rate

PUMPABILITY OF DEVELOPED GREASE

.Temperature	Shear rate, second inverse	Apparent viscosity , poises
25 deg C	200	150
	20	480

ADVANTAGES

- Super thermal and oxidation stability - Urea greases do not contain any metallic group in their thickener system and thus excel in oxidation stability at high temperature
- Very good water resistance properties
- Anti-plugging property – good pumpability, good mechanical stability

- Good lubricity
- High load bearing capability
- Excellent rust and corrosion resistance properties

CONCLUSION

- The data presented in this study indicate that the developed polyurea grease possesses excellent properties suitable for use in CCM roller bearings. The application of this developed grease is expected to prolong the segment life of the continuous caster and also lead to much higher number of ‘heats’ between relubrications

- Authors express their gratitude to the management of the company to allow the paper to be published

THANK YOU