

Study on Lubrication Optimization

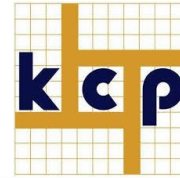
KCP Ltd- CPU-2 Muktyala

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Vijayawada

Summer Internship Programme





The KCP Ltd Management



Sri Velagapudi Ramakrishna
Founder KCP Limited



Dr. Velagapudi Lakshmana Dutt
Executive Chairman of KCP Ltd



Dr. V. L Indira Dutt
Chairperson & Managing director of KCP Ltd



Smt. V. Kavitha Dutt
Joint managing Director of KCP Ltd

Under the Supervision

V. Madhusudana Rao
CPU-2-Unit Head
KCP Limited, Muktyala



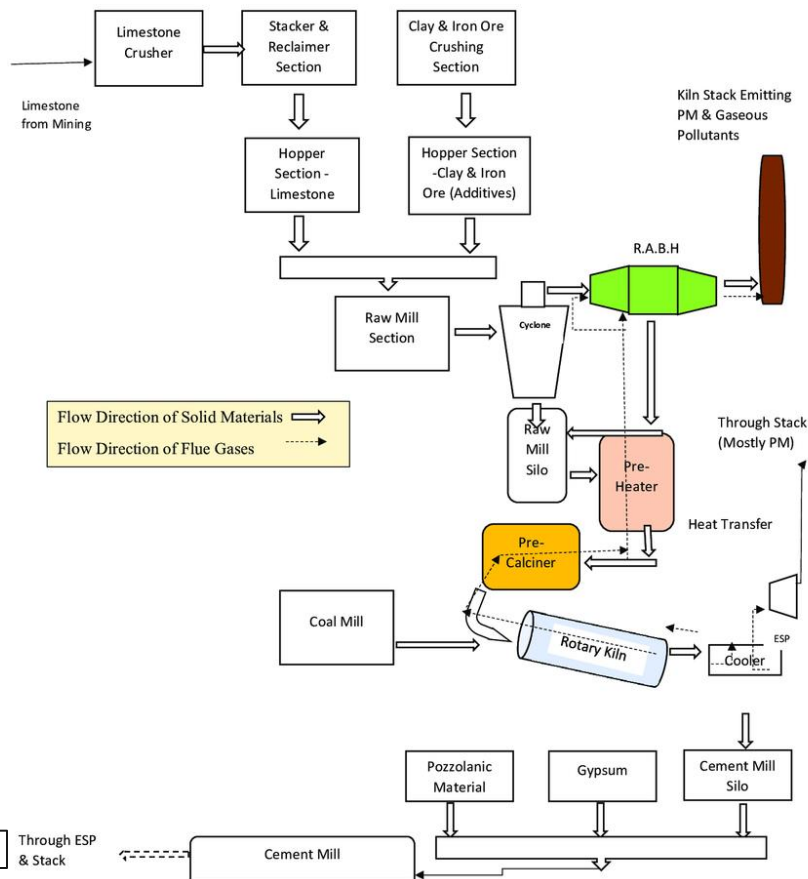
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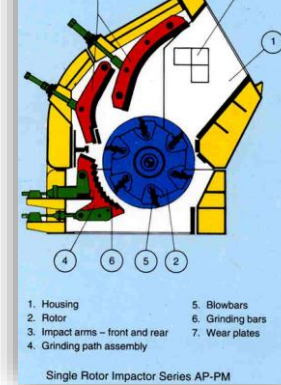
Cement Production Process





CRUSHER :-

- Crusher is used to reduce the size of limestone boulders coming from the mines.
- Input size is 1200*1000*1000 (Max) and output size is 75 mm and the capacity is 1100 TPH.



STACKER :-

- A stacker is a large machine used to stack materials such as limestone and clay in piles for efficient storage.
- Pile dimensions are 123 * 32 * 12 m



RECLAIMER :-

- Reclaimer is a machine used to recover and reclaim raw materials from piles.





RAW MILL :-

- Raw mill grinds raw materials into a fine powder which is called as raw meal.
- We use vertical roller mill (VRM) for this which has a capacity of 350 TPH.



BLENDING SILO :-

- The raw meal is stored in blending silo which has capacity of 15000 Tons.

PREHEATER :-

- Preheater preheats raw materials before they enter the kiln, improving energy efficiency and reducing fuel consumption.





KILN :-

- Kiln heats raw materials to high temperatures, transforming them into clinker. Its capacity is 4500TPD.
- Cooler cools the clinker from the kiln to a suitable temperature for further handling.



CEMENT MILL:-

- Cement mill is a facility where clinker is ground into fine powder with additives to produce cement.
- We have 2 ball mills and a VRM.



PACKAGING AND TRANSPORT :-

- Packaging and transport involve packing cement into bags or loading it in bulk for distribution and ensuring it reaches its destination safely and efficiently.





Introduction to Lubrication

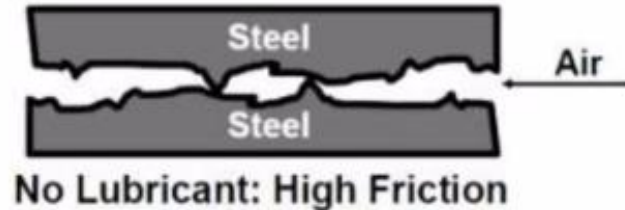
What is Lubricant?
Why is it used?
Function of Lubrication in Industry?



To control the Friction,
To control the Wear,
To control the Corrosion,
To control the Temperature,
To control the Contamination of
equipment

The substance which are used to decrease the frictional force between the two moving parts is called **Lubricant**.

The process of decreasing the force of friction between the moving parts of machine in contact is known as **Lubrication**.



Introduction to Lubrication

Types of Lubricants:

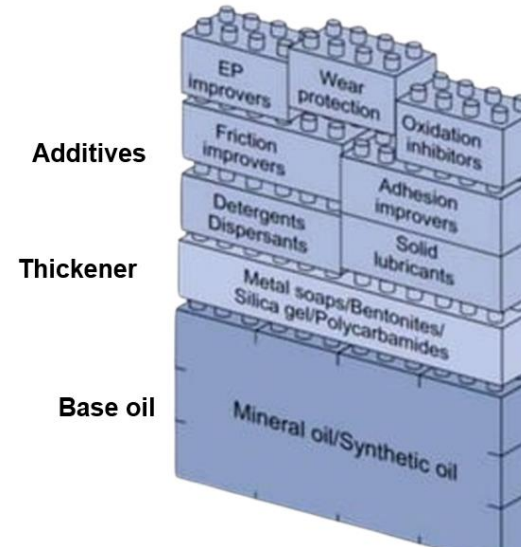
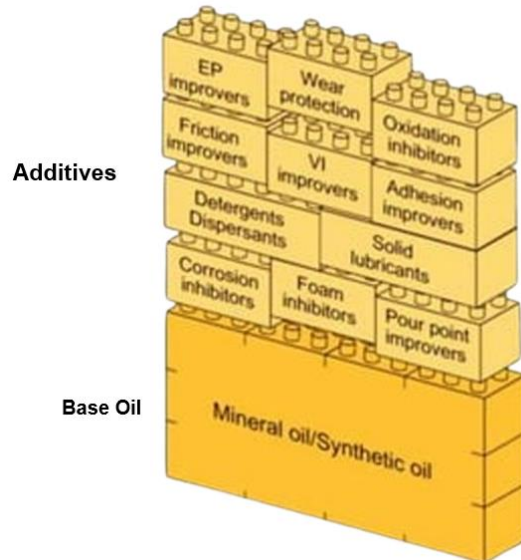
1. Solids- Graphite and Molybdenum disulfide-MoS₂
2. Liquids- Mineral oil, Synthetic oil
3. Semi-liquid - Grease

Selection depends upon on :

1. On the pressure at both surfaces area.
2. On the clearance between the bush and shaft.
3. On the motion of relative to both surfaces.
4. On the working temperature.

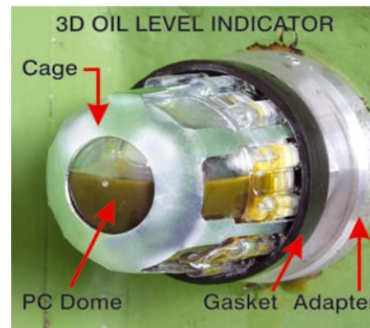
Typical lubricants – oils:

1. Gear oils
2. Turbine oils
3. Hydraulic oils
4. Compressor oils
5. Metal working oils



Lubrication Maintenance check list

- ☐ Proper Identification
- ☐ Storage in proper Environment
- ☐ Protection
 - ✓ Filter saturation indicators
 - ✓ Breather-dryer inspection for saturation
- ☐ Continuous Lubrication Inspection
 - ✓ Oil levels on machines (Min-Max level)
 - ✓ Oil quality (Oil analysis)
 - ✓ Lubricant / grease leakage
 - ✓ Storage inspection





Various types of Lubricant used in Equipment

S.No	Equipment	Component	Lubricant Name	Reservoir Cap(lit)	Limits			
					Viscosity @ 40°C ASTM D 445 in CST	Moisture in ppm ASTM D 1744	TAN in MG koh / g ASTM D 644	NAS ISO 4406:1999
1	L S Crusher Hydraulic Sytem	Hydraulic System	Servo 68	250	61.2 - 74.8		1.0 max	< 8
2	L S Stacker Boom Hydraulic system	Hydraulic System	Servo 68	250	61.2 - 74.8	500 max	1.0 max	< 8
3	Reclamer Main Drive	Gear Box	VG 460	183	414 - 506	500 max	1.0 max	< 8
4	Reclamer Harrow Hyraulic System	Hydraulic System	Servo 68	400	61.2 - 74.8	500 max	1.0 max	< 8
5	Coal Stacker Hydraulic System	Hydraulic System	Servo 68	80	61.2 - 74.8	500 max	1.0 max	< 8
6	Coal Stacker Truck Loader Hydraulic System	Hydraulic System	Servo 68	200	61.2 - 74.8	500 max	1.0 max	< 8
7	Raw Mill -1 Main Drive Gearbox	Gear Box	Mobil Gear oil 600 XP 320	4000	288 - 352	500 max	1.0 max	< 8
8	Raw Mill -1 Hydraulic System	Hydraulic System	Shell HLP 46	450	41.4 - 50.6	500 max	1.0 max	< 8
9	Raw Mill -1 Sperator Gearbox	Gear Box	Shell GX 320	48	288 - 352	500 max	1.0 max	< 8
10	Raw Mill -2 Main Drive Gearbox	GEAR BOX	SHELL S4GX 320	4000	288-352	500 max	1.0 max	< 8
11	Raw Mill-2 Rollers 1,3	Roller Bearing	SHELL S4GX 320	70	288-352	500 max	1.0 max	< 8
12	Raw Mill-2 Rollers 2,4	Roller Bearing	SHELL S4GX 320	70	288-352	500 max	1.0 max	< 8
13	Raw Mill-2 HSLM-1 Hyd system	Hydraulic system	SHELL HLP 68	450	61.2-74.8	500 max	1.0 max	< 8
14	Raw Mill-2 HSLM-2 Hyd system	Hydraulic system	SHELL HLP 68	450	61.2-74.8	500 max	1.0 max	< 8
15	Coal Mill -1 Main Drive Gearbox	Gear Box	Mobil Gear oil 600 XP 320	1000	288 - 352	500 max	1.0 max	< 8
16	Coal Mill -1 Sperator Gearbox	Gear Box	Shell GX 320	38	288 - 352	500 max	1.0 max	< 8
17	Coal Mill-2 Main Drive Gearbox	GEAR BOX	SHELL S4GX 320	1000	288-352	500 max	1.0 max	< 8
18	Coal Mill-2 HSLM Hyd System	Hydraulic system	SHELL HLP 68	230	61.2-74.8	500 max	1.0 max	< 8
19	Kiln -1 Feed Bucket Elevator	Gear Box	Mobil Gear oil 600 XP 460	210	414 - 506	500 max	1.0 max	< 8
20	Kiln -1 Deep Pan Conveyor Gearbox	Gear Box	Mobil Gear oil 600 XP 460	230	414 - 506	500 max	1.0 max	< 8
21	Kiln -1 Main Drive Gearbox	Gear Box	Mobil Gear oil 600 XP 320	320	288 - 352	500 max	1.0 max	< 8
22	Kiln -1 Thrust Roller Hydraulic System	Hydraulic System	Servo ISO VG 68	160	61.2 - 74.8	500 max	1.0 max	< 8
23	Kiln-2 Kiln Feed Bucket Elevator	GEAR BOX	Mobil gear oil 600 XP 460	210	414-506	500 max	1.0 max	< 8
24	Kiln-2 Deep Pan Conveyor Gear Box	GEAR BOX	Mobil gear oil 600 XP 460	230	414-506	500 max	1.0 max	< 8
25	Kiln-2 Main Drive Gear Box	GEAR BOX	Mobil gear oil 600 XP 320	420	288-352	500 max	1.0 max	< 8
26	Kiln-2 Thrust Roller Hydraulic	Hydraulic system	Servo ISO VG 68	160	61.2-74.8	500 max	1.0 max	< 8
27	Kiln girth gear	Gear & pinion	Ceplattyn kg 10 HMF-2500	4.104 kg per day	NLGI Grade 2	500 max	1.0 max	< 8
28	Cement Mill -1 Main Gearbox -1	Gear Box	Mobil Gear oil 600 XP 320	440	288 - 352	500 max	1.0 max	< 8
29	Cement Mill -1 Main Gearbox -2	Gear Box	Mobil Gear oil 600 XP 320	440	288 - 352	500 max	1.0 max	< 8
30	Cement Mill -1 Separator Gearbox	Gear Box	Shell Omala F 320	37	288 - 352	500 max	1.0 max	< 8

Various types of Lubricant used in Equipment

31	Cement Mill -1 Slideshoe Bearing Bearing (Inlet)	Slideshoe Bearing	Shell morlina 460	2000	414 - 506	500 max	1.0 max	< 8
32	Cement Mill -1 Slideshoe Bearing Bearing (Outlet)	Slideshoe Bearing	Shell morlina 460	2000	414 - 506	500 max	1.0 max	< 8
33	Cement Mill -2 Slideshoe Bearing Bearing (Inlet)	Slideshoe Bearing	Shell morlina 460	2000	414 - 506	500 max	1.0 max	< 8
34	Cement Mill -2 Slideshoe Bearing Bearing (Outlet)	Slideshoe Bearing	Shell morlina 460	2000	414 - 506	500 max	1.0 max	< 8
35	Cement Mill -2 Main Gearbox -1	Gear Box	Shell Omala F 320	440	288 - 352	500 max	1.0 max	< 8
36	Cement Mill -2 Main Gearbox -2	Gear Box	Shell Omala F 320	440	288 - 352	500 max	1.0 max	< 8
37	Cement Mill -2 Separator Gearbox	Gear Box	Shell Omala F 320	37	288 - 352	500 max	1.0 max	< 8
38	Cement Mill-3 Main Drive Gear Box	GEAR BOX	SHELL OMALA S2GX 320	5000	288-352	500 max	1.0 max	< 8
39	Cement Mill-3 Seperator Gear Box	GEAR BOX	SHELL OMALA S2GX 320	80	288-352	500 max	1.0 max	< 8
40	Cement Mill-3 HSMS Master Roller Lubrication	Roller Bearing	SHELL OMALA S2GX 320	1900	288-352	500 max	1.0 max	< 8
41	Cement Mill-3 HSLM Cylinder Hyd System	Hydraulic system	TELLUS S2MX 68	2200	61.2-74.8	500 max	1.0 max	< 8
42	CPP Turbine oil	Turbine	Turbinol XT46	8552	41.4 - 50.6	500 max	1.0 max	< 8
43	CPP SAC-1	Comprosser	Roto Xtend	20	41.4 - 50.6	500 max	1.0 max	< 8
44	CPP SAC-2	Comprosser	Roto Xtend	20	41.4 - 50.6	500 max	1.0 max	< 8
45	CPP IAC-1	Comprosser	Air lub XD oil	90	61.2-74.8	500 max	1.0 max	< 8
46	CPP IAC-2	Comprosser	Air lub XD oil	90	61.2-74.8	500 max	1.0 max	< 8
47	UTILITIES 541 CP2	Comprosser	Corina S3 R68	90	61.2-74.8	500 max	1.0 max	< 8
48	UTILITIES 542 CP2	Comprosser	Corina S3 R68	90	61.2-74.8	500 max	1.0 max	< 8
49	UTILITIES 561 CP2	Comprosser	Corina S3 R68	90	61.2-74.8	500 max	1.0 max	< 8
50	UTILITIES 543 CP2	Comprosser	UT Synthetic oil	65	41.4 - 50.6	500 max	1.0 max	< 8
51	UTILITIES 442 CP3	Comprosser	UT Synthetic oil	65	41.4 - 50.6	500 max	1.0 max	< 8
52	UTILITIES 441 CP2	Comprosser	Corina S3 R68	90	61.2-74.8	500 max	1.0 max	< 8
53	UTILITIES 441 CP1	Comprosser	UT Synthetic oil	65	41.4 - 50.6	500 max	1.0 max	< 8
54	UTILITIES 561 CP1	Comprosser	Corina S3 R68	90	61.2-74.8	500 max	1.0 max	< 8
55	Supporting members	Plumber block	EP 2 Grease Grade 2	70% filled out of capacity	NLGI Grade 2	500 max	1.0 max	< 8
56	Motor	Fluid coupling	Servo 68	75% filled out of capacity	61.2-74.8	500 max	1.0 max	< 8
57	Belt Conveyor	Rollers	EP 2 Grease Grade 2	40% of inner area of bearing housing	NLGI Grade 2	500 max	1.0 max	< 8



Oil Sampling :



Oil collection pump



Sample collection setup

After collecting oil samples for various equipment, we test the oil by using NAS PATCH test and analysis the report

Monitoring Lubrication Condition

Tests performed for Oil analysis

Viscosity-	Heated viscometer is used to find the viscosity at 40°C of lubricant
Moisture-	Digi test kit is used to check the moisture content in lubricant Target- 500 PPM
Contamination and wear-	Analex fd Mplus is used to find the ferrous content
Tan-	Tan drop test kit to find total acid number Target- <1
NAS-	Patch test kit is used for find the contamination level Target- <8



Patch test kit



Viscometer



Digi test kit



Ferrography



Tan drop test kit



Report Analysis:

VISCOSITY RANGES 40°C - ISO GRADE cST LIMITS							
ISO GRADE	NEW OIL ACCEPTABLE RANGE						
	-15 %	-10 %	SPEC	+10 %	+15 %	+25 %	+35 %
32	27.2	28.8	32	35.2	36.8	40.0	43.2
46	39.1	41.4	46	50.6	52.9	57.5	62.1
68	57.8	61.2	68	74.8	78.2	85.0	91.8
100	85.0	90.0	100	110.0	115.0	125.0	135.0
150	127.5	135.0	150	165.0	172.5	187.5	202.5
220	187.0	198.0	220	242.0	253.0	275.0	297.0
320	272.0	288.0	320	352.0	368.0	400.0	432.0
460	391.0	414.0	460	506.0	529.0	575.0	621.0
680	578.0	612.0	680	748.0	782.0	850.0	918.0
1000	850.0	900.0	1000	1100.0	1150.0	1250.0	1350.0
1500	1275.0	1350.0	1500	1650.0	1725.0	1875.0	2025.0
(*COMP* GEAR OILS CONTAIN 8-10% FATTY OR SYNTHETIC OILS)							

Viscosity, Moisture and TAN
(Oil Condition)

Moisture in ppm ASTM D 1744
500 max

TAN (MG koh / g) ASTM D 644
Limit : 1 Max

Normal condition: Viscosity, moisture, and TAN values are within limits.

Caution:

- High moisture: Perform **vacuum dehydration** to reduce moisture.
- Low viscosity: **Change oil.** Then thin oil film thickness between two mating parts and causes metal to metal contact to avoid lubrication related failure
- High viscosity: **Drain 20 liters of old oil and refill with fresh oil.** Then high oil film thickness between two mating parts and it can lead to Friction
- Oil change recommended if moisture exceeds **900 PPM.**

Condition is Caution or Alert if any of the three (viscosity, moisture, TAN) exceed their limits; otherwise, it's **Normal**.

NAS VALUE (Contamination and Cleaning)

Understanding NAS Values in Oils:

ISO 4406 - ISO cleanliness code

National Aero-space standards, it determines the count of particles which indicates the different size of the particles in 3 different size groups and gives results as 1st part group, 2nd part group and 3rd part group.

Let's say **18/16/13**, It means that

first part - 18 µm or largest per millilitre of fluid

Second part - 16 µm or largest per millilitre of fluid

Third part - 13 µm or largest per millilitre of fluid

NAS @ ISO 4406:1999

Limit: < 8

HOW CAN WE MEASURE HOW MUCH PARTICLE CONTAMINATION IS IN AN OIL?

Particle contamination is measured using the ISO 4406 (c) standard.

Particle Count Data	
Size in Microns	Number of Particles Larger than Size per mL
4	1654
6	495
10	122
14	52
20	21
50	1.3
75	0.22
100	0.05

Number of Particles / mL		Range Number
More Than	Less Than or Equal To	
80,000	160,000	24
40,000	80,000	23
20,000	40,000	22
10,000	20,000	21
5,000	10,000	20
2,500	5,000	19
1,300	2,500	18
640	1,300	17
320	640	16
160	320	15
80	160	14
40	80	13
20	40	12
10	20	11
5	10	10

R4/R6/R14
ISO 18/16/13

Acceptable: Decreased compared to previous value.

Higher Side: Out of range, same as or higher than previous value.

Indicates oil contamination. Filter the oil to remove excessive particulate contamination to prevent secondary wear and lube degradation.

Cleanliness Code Comparisons	
ISO Code	NAS Class
23/21/18	12
22/20/18	--
22/20/17	11
22/20/16	--
21/19/16	10
20/18/15	9
19/17/14	8
18/16/13	7
17/15/12	6
16/14/12	--
16/14/11	5
15/13/10	4
14/12/09	3
13/11/08	2
12/10/08	--
12/10/07	1
12/10/06	--

Ferrography: (Machine Condition)

- Used to study particles wear on a machine component
- It can be used to predict and diagnose errors occurring on machinery.

Ferrography Report (Machine condition) :

Normal Condition

- Normal rubbing wear particles (<15 microns) are observed in small quantities
- **Sand particles** are observed in small quantity
- **Red oxides** are observed in small quantity
- **Bearing wear particles** of size up to 38 microns
- **Gear wear particles** of size range up to 30 microns

Ferrography Report (Machine condition) :

Marginal Condition

- Normal rubbing wear particles (>15 microns) are observed in small quantities
- **Sand particles** are observed in large quantity
- **Red oxides** are observed in large quantity
- **Bearing wear particles** of size up to 106 microns
- **Gear wear particles** of size range up to 48 microns

Ferrography Report (Machine condition) :

Various ferrous wear particles

- Normal rubbing
- Severe sliding wear
- Cutting wear
- Gear wear
- Bearing wear
- Red oxides
- Black oxides
- Corrosive





Major Lubricant Maintenance Equipment



Low Vacuum Dehydration System

- LVDH is used to remove moisture content in lubricant



Depth oil filtration system

- Ability to capture and retain a wide range of contaminants



Portable Filtration Units

- These are mobile systems designed to filter lubricant on-site without the need for permanent installation

Problems Identified:



By substituting synthetic grease in the kiln girth gear and modifying the cycle time, we can reduce grease consumption and reduce lubricant cost

Theoretical quantity of grease required for Kiln Girth gear

$$0.2 \times 650 \times 24 = \mathbf{3.12 \text{ Kg per day}}$$

Where

650 mm – width of pinion

24 – hours per day

0.2 – amount of grease sprayed for every cycle in grams

Usage cycle time = 21 sec (18 sec – off, 3sec- on)

$$(3600 / 21) \times 1.1 \times 0.95 \times 24 = \mathbf{4.2 \text{ kg per day}}$$

Proposed Suggestion

By using Synthetic grease for girth gear, optimization of lubricant cost is possible

Problems Identified:

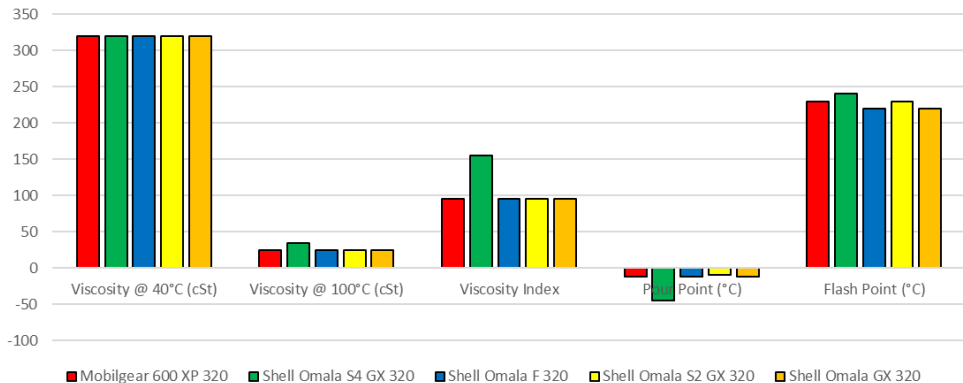
S.No	Equipment	Component	Lubricant Name
1	Raw Mill -1 Main Drive Gearbox	Gear Box	Mobil Gear oil 600 XP 320
2	Raw Mill -1 Seperator Gearbox	Gear Box	Shell GX 320
3	Raw Mill -2 Main Drive Gearbox	Gear Box	SHELL S4GX 320
4	Coal Mill -1 Main Drive Gearbox	Gear Box	Mobil Gear oil 600 XP 320
5	Coal Mill -1 Seperator Gearbox	Gear Box	Shell GX 320
6	Coal Mill-2 Main Drive Gearbox	Gear Box	SHELL S4GX 320
7	Kiln -1 Main Drive Gearbox	Gear Box	Mobil Gear oil 600 XP 320
8	Kiln-2 Main Drive Gear Box	Gear Box	Mobil gear oil 600 XP 320
9	Cement Mill -1 Main Gearbox -1	Gear Box	Mobil Gear oil 600 XP 320
10	Cement Mill -1 Main Gearbox -2	Gear Box	Mobil Gear oil 600 XP 320
11	Cement Mill -1 Separator Gearbox	Gear Box	Shell Omala F 320
12	Cement Mill -2 Main Gearbox -1	Gear Box	Shell Omala F 320
13	Cement Mill -2 Main Gearbox -2	Gear Box	Shell Omala F 320
14	Cement Mill -2 Separator Gearbox	Gear Box	Shell Omala F 320
15	Cement Mill-3 Main Drive Gear Box	Gear Box	SHELL OMALA S2GX 320
16	Cement Mill-3 Seperator Gear Box	Gear Box	SHELL OMALA S2GX 320



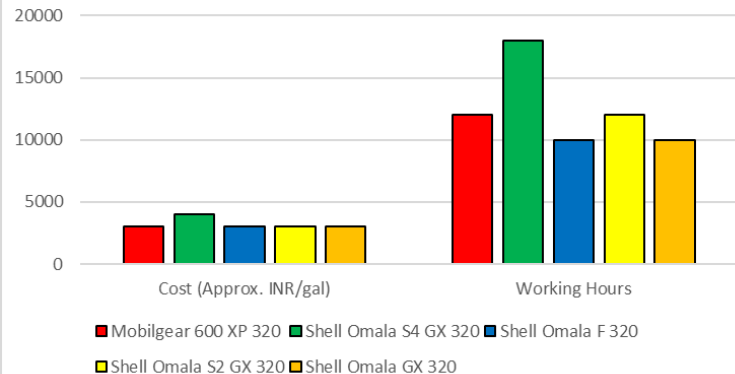
Our Suggestions

From the report analysis and properties of the lubricants

Properties of the Lubricants



Cost & Working Hours



Mobil 600 XP 320 is mineral oil and cannot withstand high temperatures, so **Shell omala S4GX 320 is preferred.**

Problems Identified in Manual Greasing



- Inconsistency
 - Accessibility
 - Manpower Engagement
- Over or under lubrication
 - Difficult to lubricate hard to reach areas

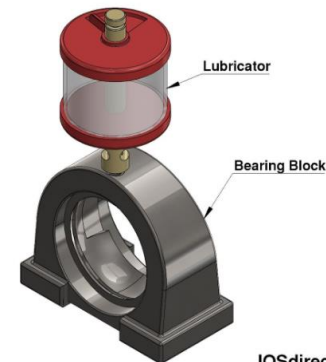
Solution - Using Automatic Grease cartridges

Advantages:

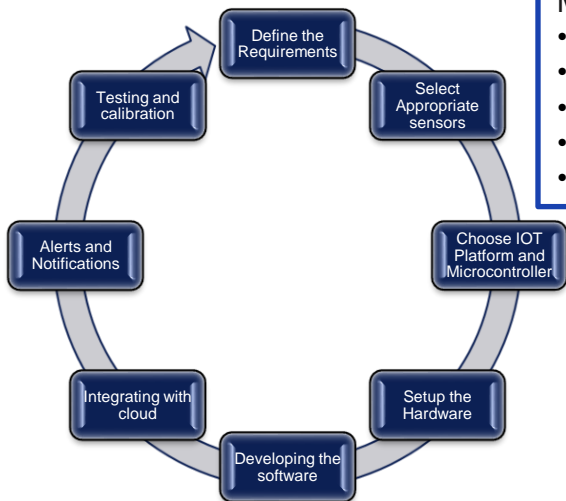
- Consistency
- Efficiency
- Accessibility

It operates independently of temperature and pressure, provides precise discharge.

Single Point Lubrication System



Smart Grease Cartridge using IOT



Major Areas to place these cartridges

- Deep pan conveyor gear box
- Pre Heater-Feed RAL
- Conveyor belts Motor Bearings
- Fans
- Blowers

The cost of these cartridges is based on the amount of lubricant they hold.

On average, a cartridge with a 500 ml capacity costs 750 rupees.

Components required for Smart Grease Cartridge using IOT

- Capacitive level sensor (BHC-SR04)
- Temperature sensor (DSB20)
- Microcontroller (ESP-32)
- Cloud platform (Think speak. AWS IOT core etc.)

Cost for implementing this IOT system ₹4000 per Piece

By implementing this IOT system for these cartridges we can reduce human errors and Machine Failure



Thank You!