

High Performance Grease for Tyre Press Mould Application

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Abstract

Tyre manufacturing is ever growing industry which annually produces more than a billion tyres world over. Standardized tyre manufacturing process includes mainly of compounding and mixing, component manufacturing, assembly, curing and finishing steps. Out of these steps 'curing' is the process where the shape of the tyre is set under extreme pressure and considerable heat using either mechanical or hydraulic press mould. Smooth functioning of the press mould parts is critical to the final shape of the tyre as the process lasts form 15 minutes to few hours depending on the size of the tyre. Therefore lubrication of the drive mechanism of the press mould including pistons, valves, gears, etc. requires specially designed grease. In this work, a high performance grease specially developed for lubrication of tyre press moulds is presented. Detailed laboratory evaluation and field experience on this product will also be discussed.

Key Words: Press Mould, Tyre Manufacturing, Lubricating Grease, Curing

Introduction

“Invention of wheel” is undoubtedly the most ‘valuable invention’, which set the human civilization rolling on the track of growth through industrialization. Tyre manufacturing industry directly or indirectly influences almost all of the modern industries including automotive, mining, transport etc. Over a billion tyres are produced worldwide annually. From the early days of producing tyres merely by sticking natural rubber plies on to steel frames, tyre manufacturing now has become a complex process. Tyre manufacturing mainly involves compounding and mixing, component manufacturing, assembly, curing and finishing steps. These steps are performed by a variety of machines performing mixing, extruding, calendaring, moulding and milling processes. Typical tyre components are natural / synthetic rubber, carbon black, silica, sulphur, steel, antioxidants, copper, process oils, cross-linkers and textile fibers. After going through a complex processes, a mixture of these components takes the *characteristics shape of a tyre* through ‘curing’ process which is performed in a press moulding machine. The ‘green tyre’ as it is termed commonly at this stage is filled in moulds under high pressure and temperature to allow final curing reaction to take place. This stage is critical to tyre manufacturing as final shape, appearance and characteristics are acquired by the tyre at the end of this stage. No further chemical modification is possible after this stage. Only tyre shaping is done afterwards. Therefore smooth functioning of all drive mechanisms of the press moulding machine is critical. This requires application of specialized oils and greases.

Greases are commonly used for lubrication of ‘tyre press mould bearing’ of both mechanical and hydraulic type of presses. Typical performance determining parameters include working under high pressure and heat. To tap this niche area of lubricants a research programme was initiated to develop, a grease suitable to lubricate bearings of ‘tyre press moulding machine’. This research work presents development, evaluation and field performance studies of newly developed grease for “Bearings and gears of Tyre Moulding Press”.

Experimental

Greases were produced by 'batch process' in a closed pressure kettle under controlled experimental conditions such as temperature, pressure etc. Manufacturing process was established by repeated production of successful batches both at bench and pilot plant scales. Successful batches were tested as per standard test methods such as ASTM, IP, etc. against a set of specifications framed to develop grease. Batches meeting the physico-chemical properties were also tested for tribological properties in rigs. Best performing product was selected for field evaluation studies at a reputed tyre producing site.

Results and Discussion

Typical properties of developed grease are given in Table 1. A based grease was developed in NLGI 1 consistency with excellent mechanical stability (Penetration change after one lakh double strokes is 10 units only).

Table 1- Properties of grease developed for bearings of press mould

Property	Test Method	Typical Result
<i>Consistency</i>	ASTM D 217	NLGI Grade 1
<i>Thickener</i>	--	Proprietary
<i>Worked Penetration</i>	ASTM D 217	321
<i>Penetration change after 10⁵ strokes</i>	ASTM D 217	10
<i>Dropping Point</i>	ASTM D 566	> 200° C
<i>Copper Corrosion Test</i>	IP 112	Pass
<i>Base Oil Type</i>	--	Mineral
<i>Heat Stability, (oil separation), % Wt.</i>	ASTM D 6184	< 5.0
<i>Four Ball Weld Load</i>	IP 239	> 250 Kg
<i>Wear Scar Diameter</i>	ASTM D 2266	< 0.50 mm
<i>Emcor Corrosion Test, Rating</i>	IP 220	0,0

Grease was designed to have dropping point $> 200^{\circ}\text{C}$ and minimum oil separation ($< 5.0\%$) at elevated temperature. Grease was found to pass copper corrosion and Emcor corrosion tests. Typical weld load was $> 250\text{ Kg}$ producing $< 0.50\text{ mm}$ wear scar diameter. The relativeness of these properties in context to the field performance is discussed further.

Field Evaluation

Performance of developed grease was field tested at a reputed tyre manufacturing unit. Product was evaluated in a typical single press moulding machine. Machine mainly comprises of frame, mould opening/closing device, mould adjusting device, center mechanism, curing chamber, tire loading device, tire unloading device, hydraulic system, electrical system, pipeline system and post cure inflator etc. A 37KW motor operates the ~ 38 tonnes machine. Mould (220 – 520 mm in height) consists of two circular rings which open / close with help of hydraulically driven pistons. Grease lubricates the bearings of this mould. Grease from a reservoir is fed to sealed mould bearings through pump at typically 2000 psi pressure. In the lower ring seat of mould green tyre is filled. Inner of the mould is inflated with the help of a bladder which contains a recirculating heat transferring medium. Temperature inside the tightly secured mould reaches to 350°F with pressure around 350 psi. Curing reaction takes place for around 15 minutes to few hours depending on the tyre specifications. At the end of the reaction the pressure is released and mould is opened up. Tyre is stripped off from the mould for finishing process.

Grease softening resulting into leakage from the bearings and higher grease consumption were the major problem faced by the party. The developed grease (NLGI 1) was found optimum for easy pumping of the grease from reservoir. Grease could be smoothly fed to the bearings at 2400 psi. Dropping point $> 200^{\circ}\text{C}$ made use of the grease safe under the conditions (350°F). No rusting of copper or any other metallic part of the machine as reported for the period of trial. Typical mould closing force of 1700 KN is also supported by bearings of the mould. Four ball weld load $> 250\text{ Kg}$ gave satisfactory performance of grease even at high pressures 250 psi. No seal rupture or bearing failure was reported. Minimum grease change time was found to increase from 9 days (for earlier grease in use) to 17 days. Grease was found

to compatible with seal and grease transporting hose material. This grease is running successfully now for more than three months at the trial site.

Conclusion

An NLGI 1 grade consistency grease was developed for lubrication of '*bearings of tyre press mould*' and it was successfully evaluated at a reputed tyre manufacturing site. During evaluation use of grease increased grease change interval from 9 to 17 days. Use of grease was found safe under high temperature and pressure.

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