



Enhanced Oil Recovery

Full Field Polymer Application

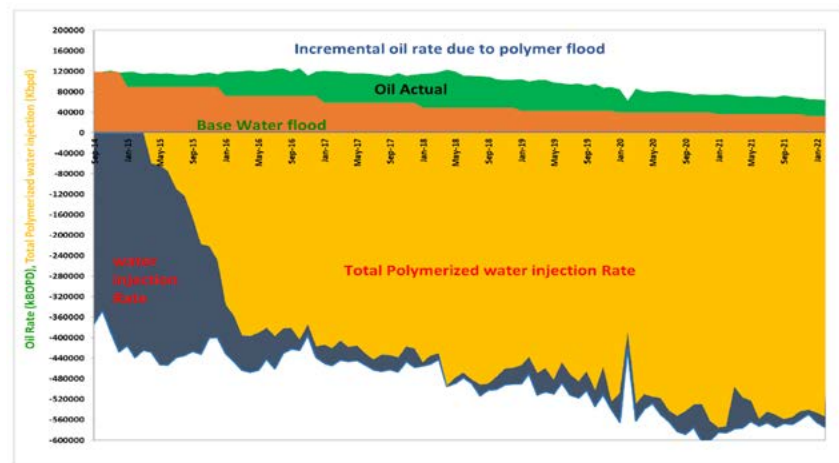
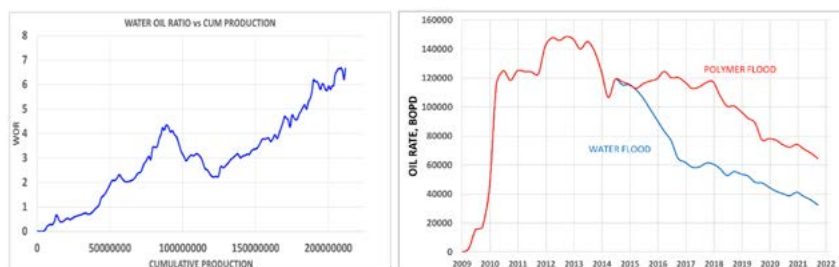
Mangala Field

Polymer injection was ramped up to initial target rate of 400k bpd by February 2016. The world-class polymer project in Mangala has been successfully implemented and stabilised within a span of one year, making it one of the fastest and largest polymer flood applications in the world. As on date post multiple infill projects, polymerised water is being injected at an average rate of 470k bpd. Current injection level has been successfully maintained with proactive and efficient management of surface facilities, wells and reservoir. Incremental EOR contribution due to polymer flood has exceeded over 120mmstb over the last 9 years.

Based on the success of polymer injection in Mangala field, implementation of polymer flood in other two fields, Bhagyam and Aishwariya, has also been commenced

Bhagyam Field

Bhagyam is a sister field of Mangala in Barmer basin, Rajasthan and chemical EOR was identified as the most suitable EOR method namely polymer and ASP. In Bhagyam, a limited polymer pilot started with long term polymer injectivity test during year 2016. Upon good response in nearby well, later it was extended to 8 wells and continued for four years while preparation for field scale polymer flood was underway. Field



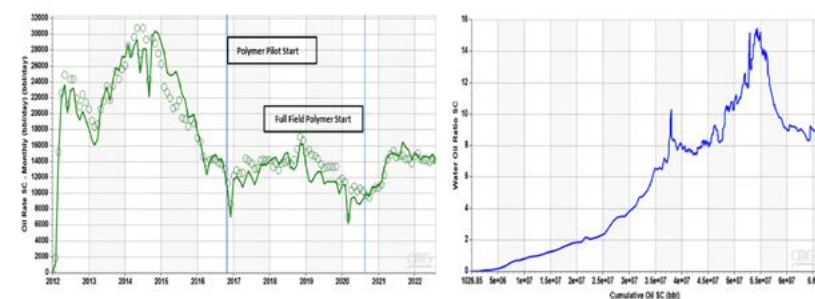
scale polymer expansion plan included drilling of 28 new infill wells (17 P+ 11 I) and 24 producer-to-injector conversions. Modular skid-based polymer preparation units were installed to meet the injection requirements of the expansion plan. As a learning from Mangala field, buffer vessels (horizontal cylindrical vessel) at polymer pump suction and underground pipeline were introduced to avoid vibration issue. This has helped in ramping up injection without any major surface issues. Infill producers were brought online in 2018 as per the plan and production rate was sustained without significant decline, aided by continuous polymer injection in initial eight injectors, continuing water flood and good reservoir management practices. First polymer injection in field scale expansion started in October 2020 and was quickly ramped up to the planned 80000 BPD in four months, supported by analyses of surveillance data, indicating very encouraging initial production response. Laboratory quality check program was designed to check quality of polymer during preparation and to ensure viscosity integrity till the well head.

A significant drop in the field produced water oil ratio is seen. Produced WOR

dropped from 16 (at the onset of polymer flood) to 8 and is currently in the range of 11-12 after 4 years of injection. Drop in WOR is observed in producers across all the areas of the field. Figure below shows oil rate and WOR trends post polymer injection ramp-up. Field oil rate was approximately 10.5 KBOPD before polymer injection ramp-up in October 2020. The production rate showed a drastic increase to 14-15k bopd (peaked at 16). The field is currently producing at ~10k bopd after 4 years of full field polymer injection.

Aishwariya Filed

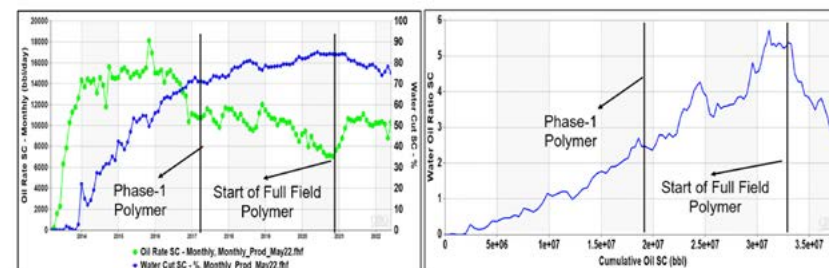
Aishwariya is also a sister field to Mangala in Barmer basin, Rajasthan and chemical EOR was identified as the most suitable EOR method. The polymer flood in Aishwariya field was implemented in two stages. In the first stage, a polymer injectivity test was conducted in three wells to establish the potential for polymer injection in these wells. The study was extended to three more wells and continued for nearly four years. Significant water cut drop was observed in nearby wells during this phase of polymer injection. In the next stage, polymer flooding was extended



to the entire Lower Fatehgarh sands unit with drilling of 14 new infill wells and converting 8 existing wells to polymer injectors. A 14 km long pipeline was laid from the Mangala Central Polymer Facility to well pads in the field to cater to the requirement of 6-8 KBPD of ~15000 ppm polymer mother solution. Currently it is the world's longest pipeline to carry concentrated polymer MS. Field scale polymer injection was started in 2020 and injection was ramped up to the planned ~35-45 KBPD of polymerized water within a month owing to good injectivity

and polymer solution quality. A detailed laboratory, well and reservoir surveillance program has been implemented and the desired wellhead viscosity of 25-30 cP has been achieved.

The initial results from the implementation of polymer flood in the Aishwariya field are very encouraging. Post ramp-up of polymer injection, field oil rate increased from ~12 KBPD to ~15.5 KBPD. Lower Fatehgarh unit oil rate has increased from ~7000 bopd to ~10700 bopd.



Going forward further infill and polymer expansion is planned in Bhagyam and Aishwariya fields. Additionally, planning for Mangala large scale ASP flood and ASP pilots are being planned in

Bhagyam and Aishwariya fields. The current assessment of the EOR resource base is 400-500 mmbbls of incremental recoverable oil from the three Mangala Bhagyam Aishwariya (MBA) fields.



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