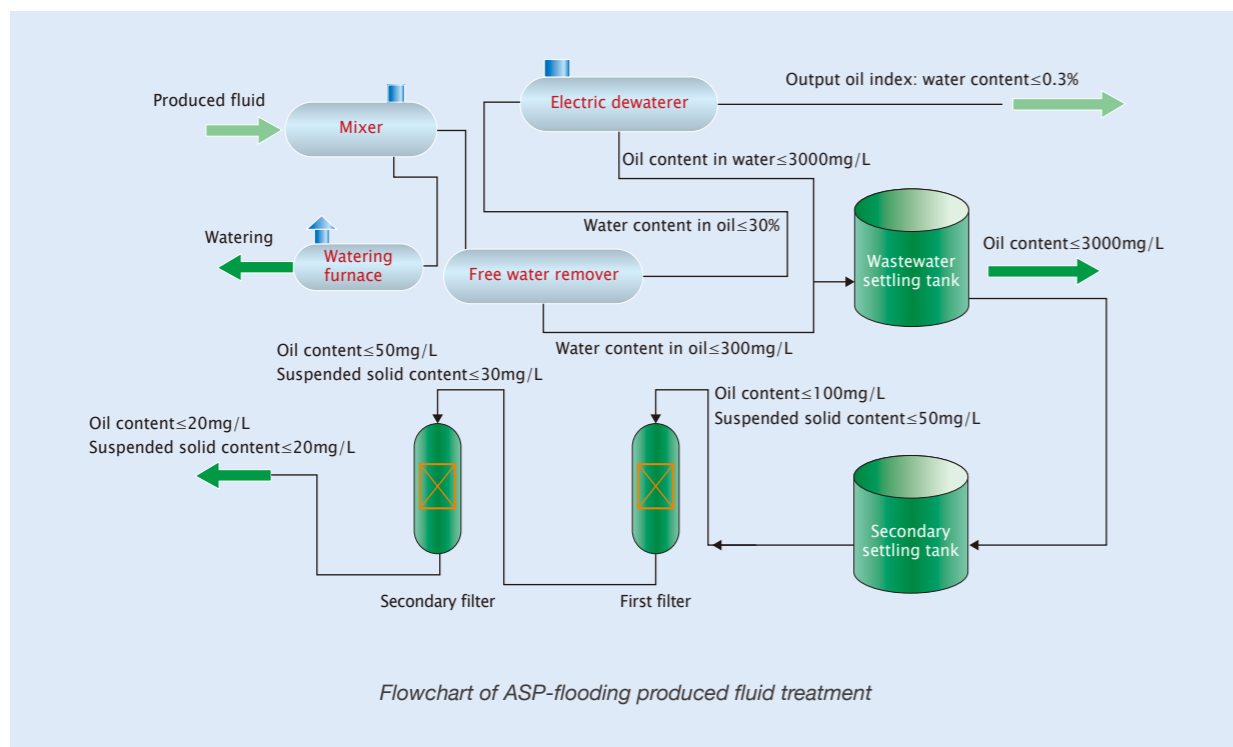


A four-stage treatment process consisting of two stages for oil removal and two other stages for filtering has been developed and put into application to treat produced water by ASP flooding. The system outputs water that meets national discharge standard (oil content $\leq 20\text{mg/L}$ and suspended solid content $\leq 20\text{mg/L}$).



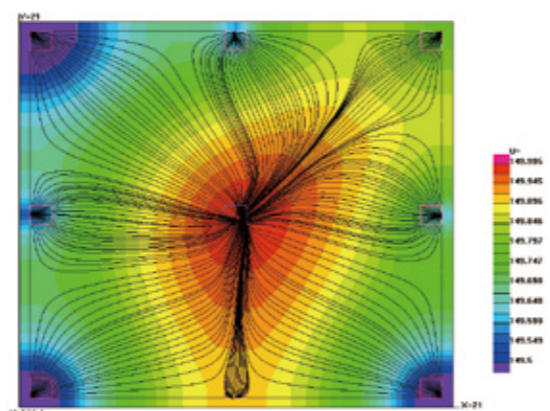
Increase Oil Recovery

CNPC's major oilfields, after underwent natural energy depletion, have generally experienced three development stages: early water flooding, separate layer water injection and separate zone adjustment, and tertiary recovery.

Because the continental reservoirs in these oilfields are of strong heterogeneity and higher crude viscosity, the recovery efficiencies by water flooding are generally 30%-40%. At present, all these oilfields are in late high-water-cut development period, with total water cut up to 80%-90% or even higher.

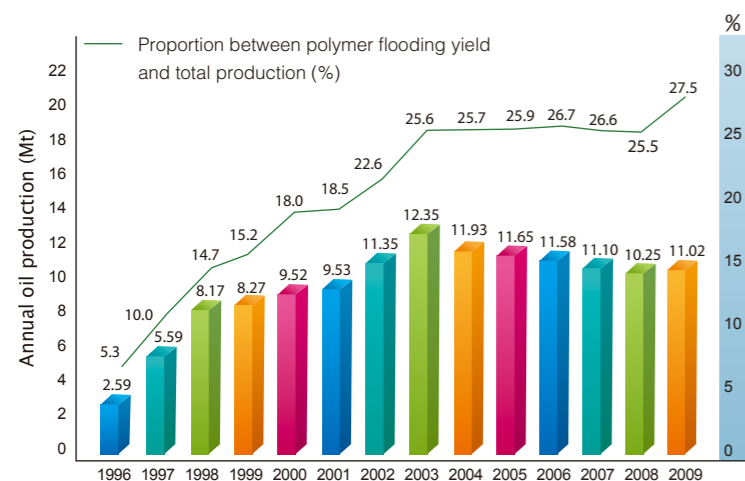
Considering the dramatically rising exploration expenditures and the challenging recovery of new reserves, we mainly took two measures to further improve the ultimate recovery of mature oilfields: (1) finely controlled water flooding, to continuously expand the swept volume and flushing intensity; and (2) tertiary recovery focusing on chemical flooding.

In recent years, we have continuously promoted "finely controlled water flooding" on the basis of fine reservoir description in mature oilfields. Based on accurately quantified remaining oil distribution, we adopt a separate layer water injection approach which includes subdividing development layer series, adjusting injector/producer system, and increasing separate injection capacity, and also implement large-scale fracturing, acidizing, water shutoff and profile control, in order to effectively displace the remaining oil and increase the rate of producible reserves and per-well output. In 2013, the natural decline rate and composite decline rate of our oilfields were well controlled, with the rise in water cut less than 0.5% for the fourth consecutive year. The water flooding recovery reached about 50%.



Apart from water flooding, we have conducted tertiary recovery dominated by chemical flooding. We have made remarkable progress and achievements in the R&D and application of polymer flooding, ASP flooding and ASP-foam flooding, making us one of the world leaders in the technology as well as application scale in chemical flooding for EOR.

In Daqing Oilfield, a technical package for polymer flooding has been developed and proven successful, which include oil displacement mechanism, oil layer adaptiveness, optimization of injection parameters and modes, and tracking/adjustment during polymer flooding process.



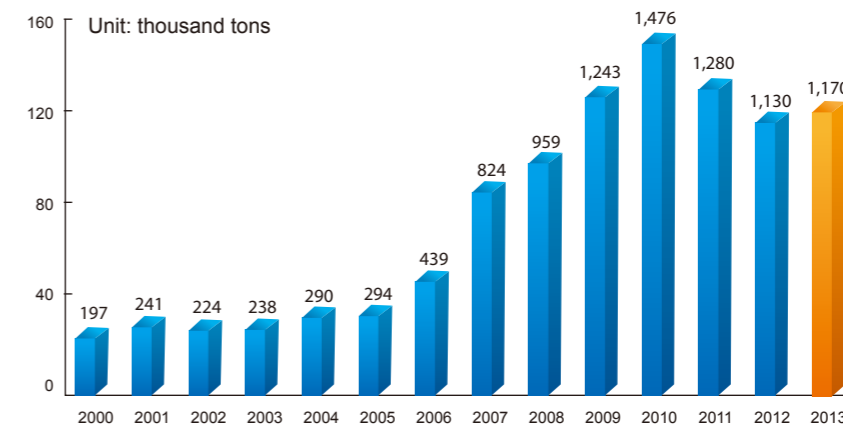
Oil output by polymer flooding in Daqing Oilfield

We have developed a new type of comb-shaped and salt-tolerant polymer, which delivers favorable results in Daqing Oilfield: additional 100-120 tons of crude can be produced by injecting one ton dry powder of such polymer, and 10% higher recovery efficiency than by water flooding. In Daqing, polymer flooding can yield 12 million tons of crude oil on a yearly basis.

Closed cyclic operation is adopted throughout the whole process of polymer flooding, during which the produced water is treated and re-injected in reservoirs, and polymer solution is circularly prepared to realize zero discharge.

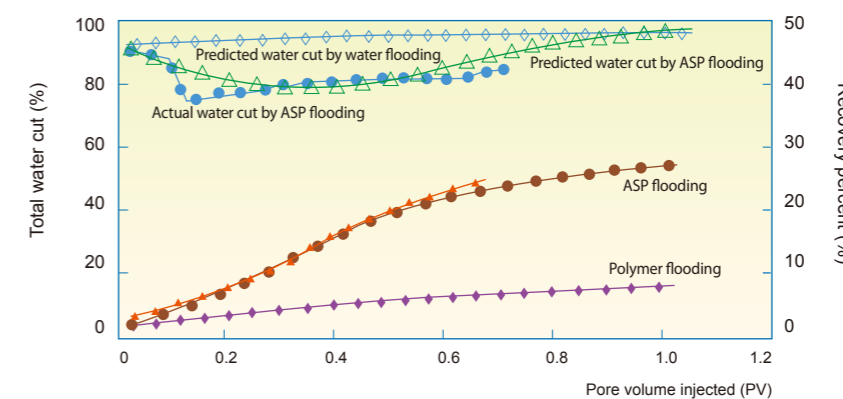
As to ASP flooding, techniques for formula optimization, injection allocation and scale cleanout/prevention have proven practical. Lab and field tests yield recovery efficiencies 10% higher than by polymer flooding. ASP flooding has been put into industrial application in Daqing and Xinjiang oilfields.

Up to now, ASP flooding has been deployed in four industrial pilot zones and six industrial zones in Daqing Oilfield, with the producing reserves of 39.59 million tons. ASP flooding has cumulatively yielded 9.37 million tons of crude, and contributed more than one million tons of crude production each year in the past four years. In 2014, ASP flooding will be rolled out in a larger scale, with the producing reserves of 47.18 million tons. The ultimate recovery is expected to be enhanced by more than 18%.



Oil output by ASP flooding in Daqing Oilfield

ASP-foam flooding is a new EOR technology, or an advancement of foam flooding and ASP flooding. As a CNPC's innovation following polymer flooding and ASP flooding in the field of chemical flooding for EOR, it uses a new flooding system consisting of alkaline, surfactant, polymer, and natural gas. The recovery efficiency by ASP-foam flooding can be 10% higher than by ASP flooding and 30% higher than by water flooding, as indicated by lab and pilot tests.



ASP flooding and polymer flooding results in Duandong of Bei-1 block, Daqing Oilfield