

"Benefits of Reduced Coking in Steam Cracking with ANK400 Technology"

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Introduction

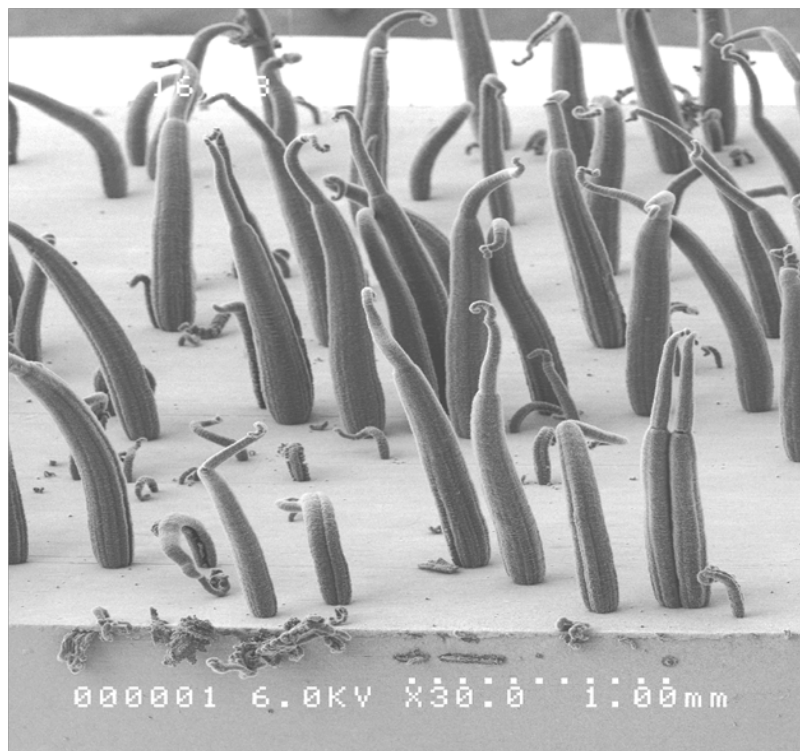
- Olefins production through steam cracking is highly energy and capital intensive:
 - ▶ A very detrimental result of the cracking process is the formation of coke.
 - ▶ Coke deposits in cracking coils, quench exchangers and other downstream equipment resulting in:
 - Loss of heat transfer and thermal efficiency.
 - Carburization of coils and components.
 - High maintenance costs and reduced furnace availability.
 - High pressure drop and reductions in furnace throughput.
 - Reduced product yields.

Coking Influences

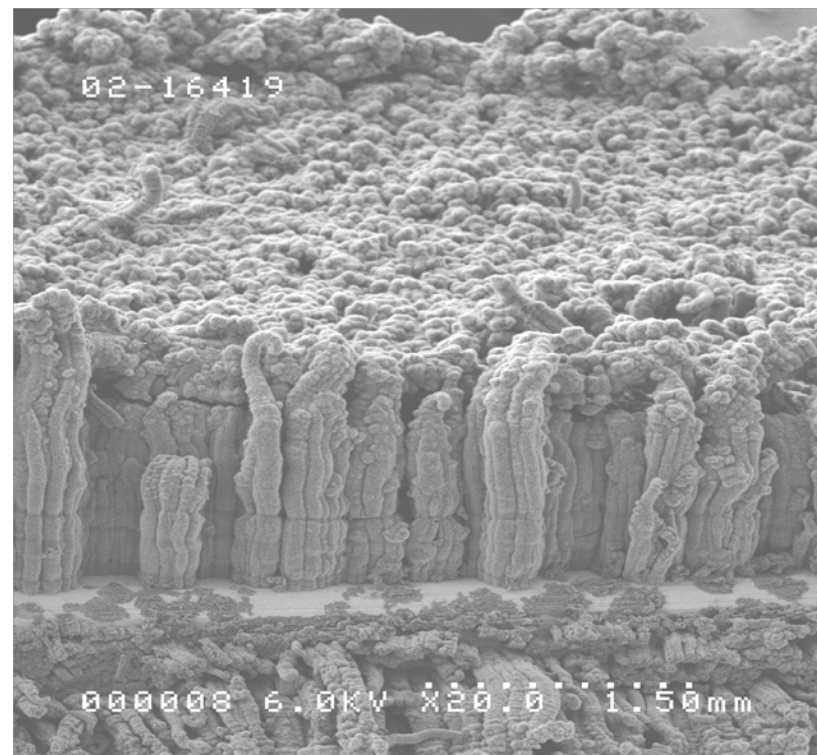
- ▶ Many factors influence rate and type of coking:
 - Feedstock composition
 - Cracking severity
 - Furnace and coil design
 - Coil and component metallurgy
- ▶ Mechanisms and influences are not always well understood.
- ▶ Often the coil tube surface reactivity is the largest contributor to coke make.
 - Nickel and iron in the bulk tube metal act as catalysts to coke formation.
 - Minimizing this impact has been the focus of many technologies and operating practices in the ethylene industry.

Catalytic Coke

- Dominant form of coking, particularly in gas cracking.
- Highly insulating and unstable structure.
- Promotes other forms of coking.



Early Stage: Initiated as hair like filaments with active nickel particle at tip.



Late Stage: Filaments grow in length and breadth resulting in a thick porous coating.

NOVA Chemicals

- NOVA Chemicals operates 4 Ethylene Plants - 3 Ethane Crackers at Joffre Alberta, Canada, 1 Flexi-Cracker at Corunna Ontario, Canada, Total of 41 Cracking Furnaces.
- Also operates a research facilities at Calgary Alberta, Canada.
- As a producer, investigated all available anti-coking technologies.
 - In 1992 initiated a research project to develop its own anti-coking technology.
 - Utilized NOVA Chemicals Research and Plant facilities to test and evaluate developments.

ANK400 Technology

- Objective: Produce an inert barrier on the internal surface of the cracking tube to prevent catalytic influence of the coil.
 - ▶ Needed to be robust and stable to withstand the severe cyclic conditions of the cracking coil.
 - ▶ Needed to be manufactured at a reasonable cost.
 - ▶ With no negative impacts to coil life or downstream processes.
- Achieving all criteria proved difficult.
- Resulted in hundreds of lab trials and over forty field trials over a 16 year period.

ANK400 Technology

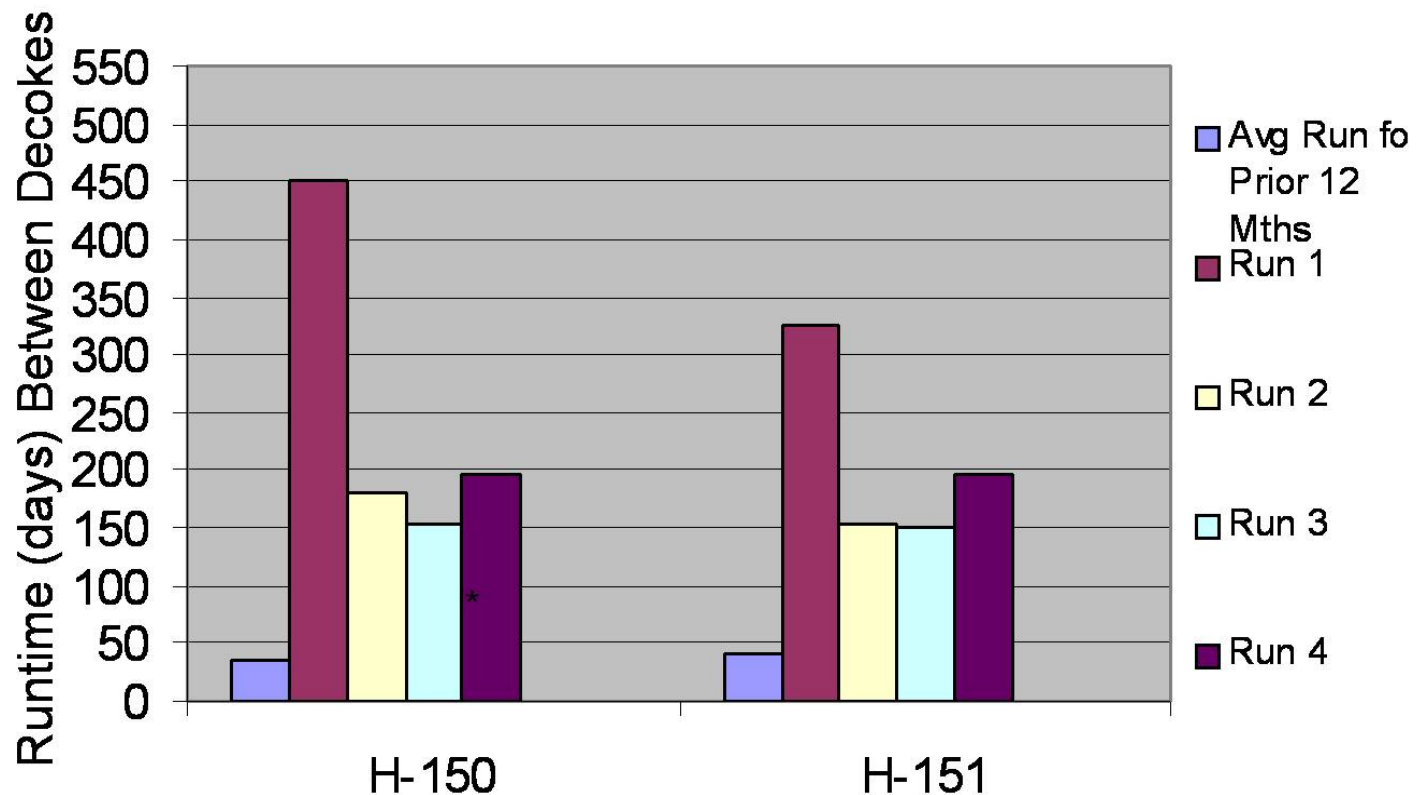
- The result of this research and development has been the proprietary **ANK400** technology which produces a stable inert spinel on the surface of the cracking coil.
 - Demonstrating ability to reduce coking rates by as much as 90%.
- In 2002, after achieving very significant reductions in coke make in furnaces at Joffre, NOVA Chemicals entered into a license agreement with Kubota Metals Corporation to allow manufacture and marketing of ANK400 technology to the ethylene industry.

Performance achieved at NOVA Chemicals

- Benefits of coke reduction observed at individual furnace level many times.
- Now with ANK400 fully implemented in Joffre E1 & E2 plants the benefits of very low coking rates have been quantified at a plant level.
 - ▶ The following furnace process data represents performance of Ethylene 2 furnaces at Joffre.
 - ▶ The following benefits presented are calculated based on the combined benefits achieved in Ethylene 1 and Ethylene 2. (Total of 20 cracking furnaces)

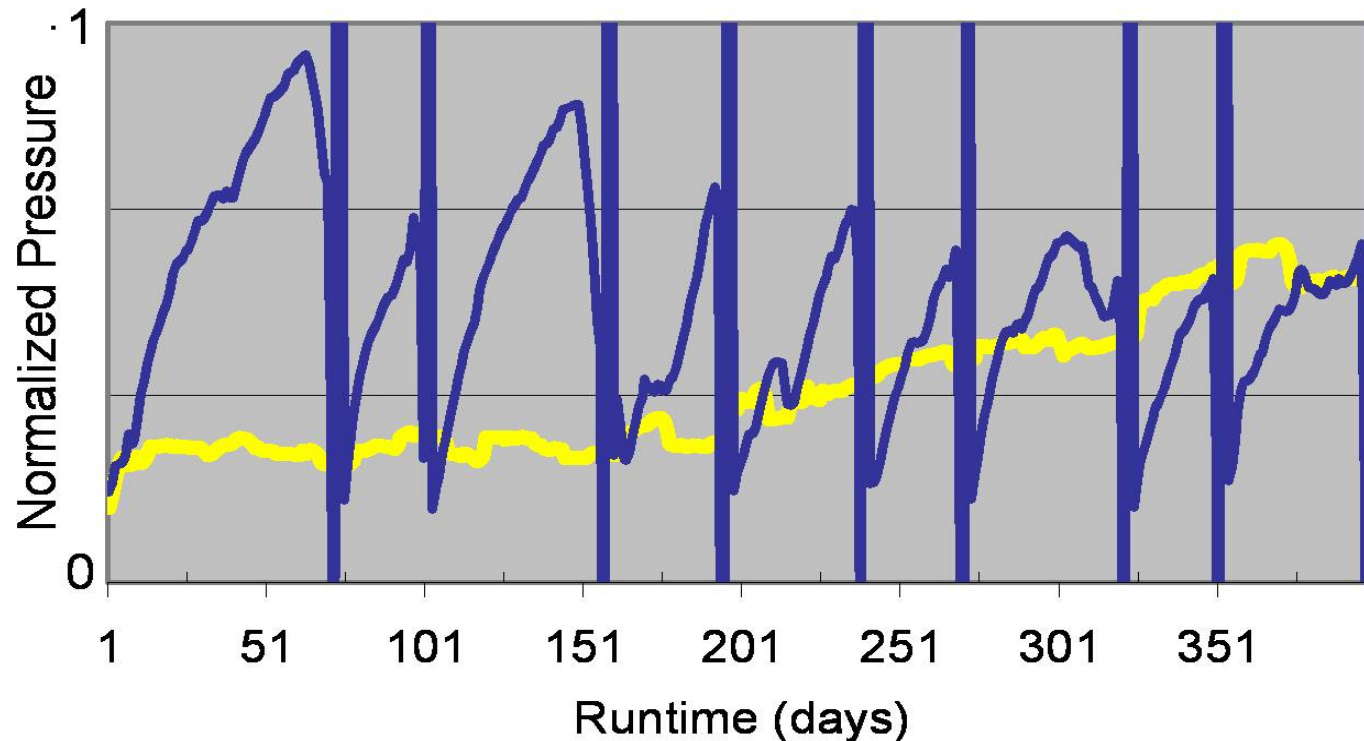
Extended Run-Lengths between decokes

- Standard coil run-lengths averaged 33 days.
- ANK400 run-lengths 150 to 450 days.



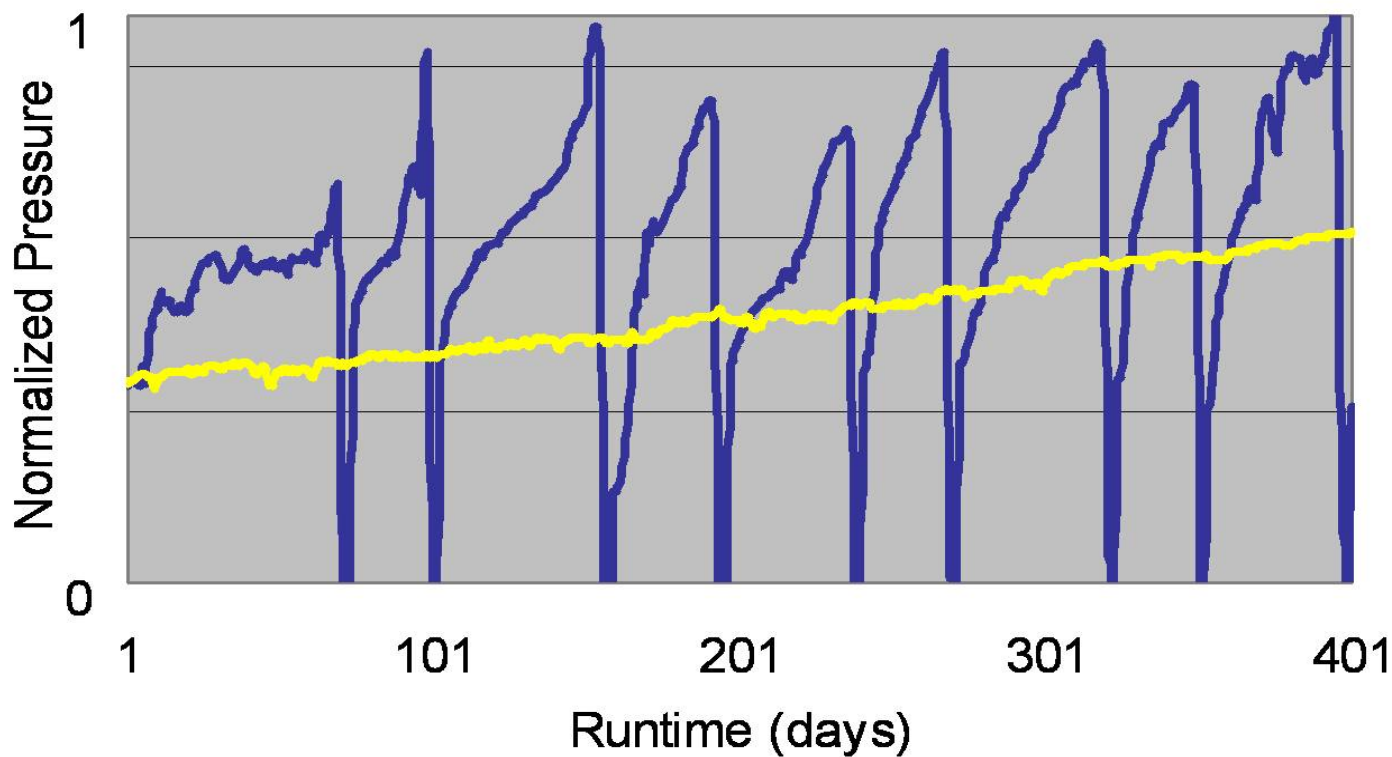
Coil Pressure Drop Reduction

- Chart indicates normalized coil pressure drop over 400 day period.
- Standard coil furnace(blue) shows very rapid rise in coil pressure drop. Required 9 decokes during period.
- ANK400 coil(yellow) very low rate of pressure drop increase. No decokes required through 400 day period.



TLE Pressure Drop Reduction

- Chart indicates normalized TLE pressure drop over 400 day period.
- Standard coil furnace(blue) shows very rapid rise in TLE pressure drop. Required 9 decokes during period.
- ANK400 coil(yellow) very low rate of pressure drop increase. No decokes required through 400 day period.



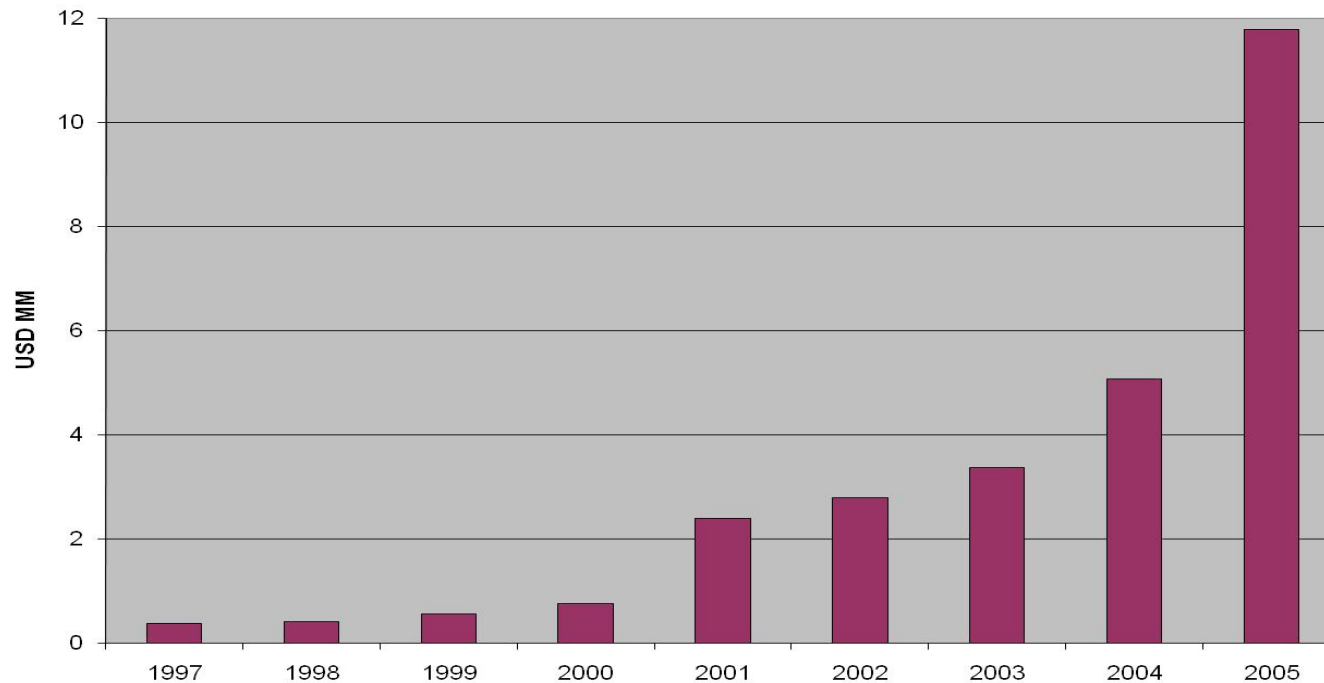
Plant Benefits achieved at NOVA Chemicals

- Benefits of longer run-lengths and reduced pressure drop provided by ANK400 have been quantified from years 1997 through 2005.
- Increased annual benefits due to installation of additional ANK400 furnaces as coil replacements occurred.
- Benefits Measured:
 - ▶ Reduced energy and chemical costs
 - ▶ Reduced maintenance costs
 - ▶ Improved furnace availability

Energy and Chemical Savings

- Reduced decoke energy requirements.
- Reduced sulphur use.
- Improved thermal efficiency due to reduced fouling of furnaces.

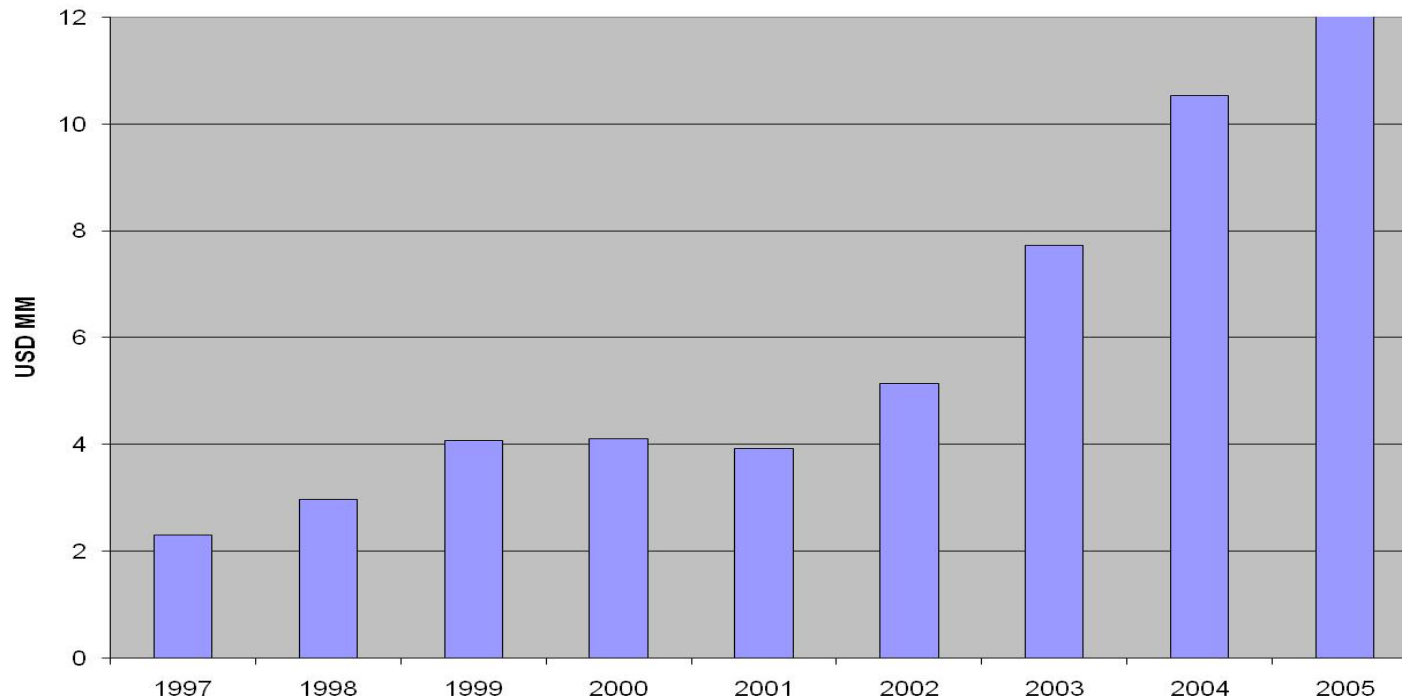
MANUFACTURING BENEFIT ACHIEVED IN E1 & E2
ENERGY SAVINGS



Maintenance Cost Reduction

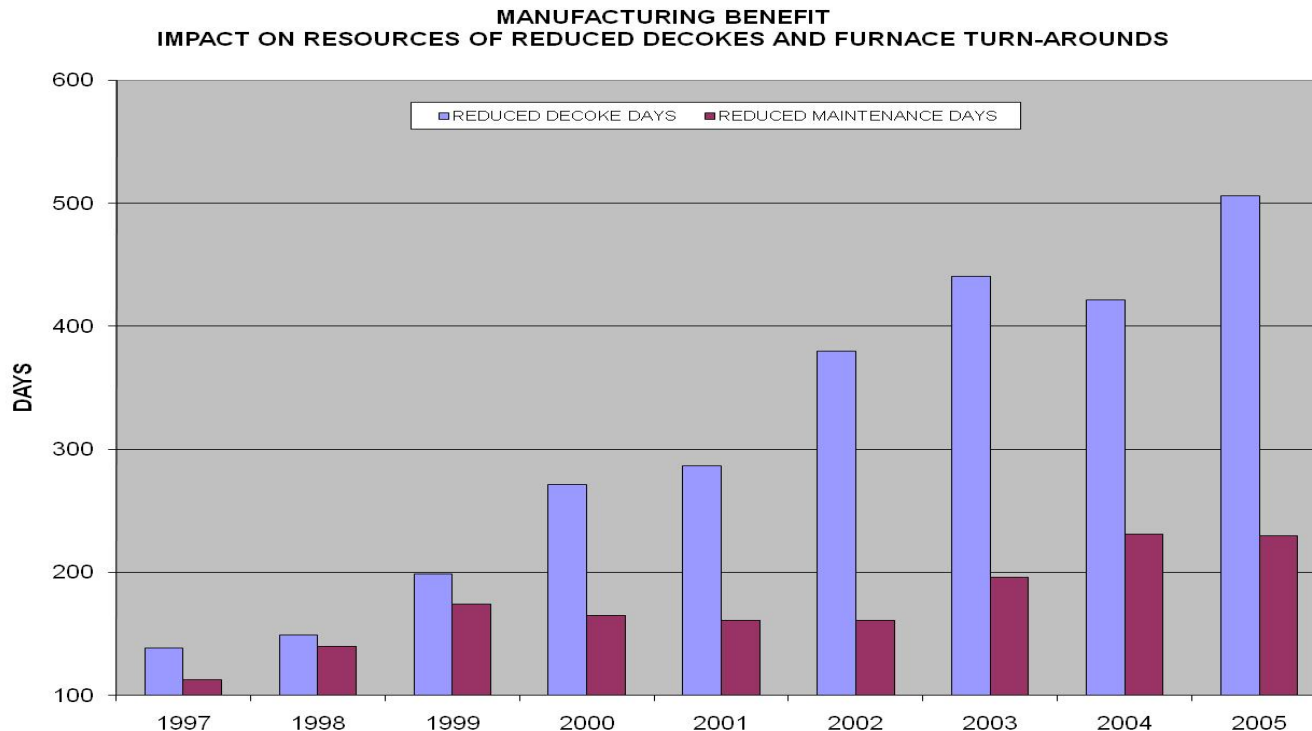
- Result of increasing furnace turnaround intervals from 6 months to 2 years.
- Reduced maintenance scope due to less fouling.
- Extended coil life.

MANUFACTURING BENEFIT ACHIEVED IN E1 & E2
MAINTENANCE COST REDUCTION



Increased Furnace Availability

- Reduction in decokes increased furnace availability by over 500 furnace days per year.
- Reduction in maintenance increased furnace availability by over 200 furnace days per year.
- 10% overall increase in furnace availability.

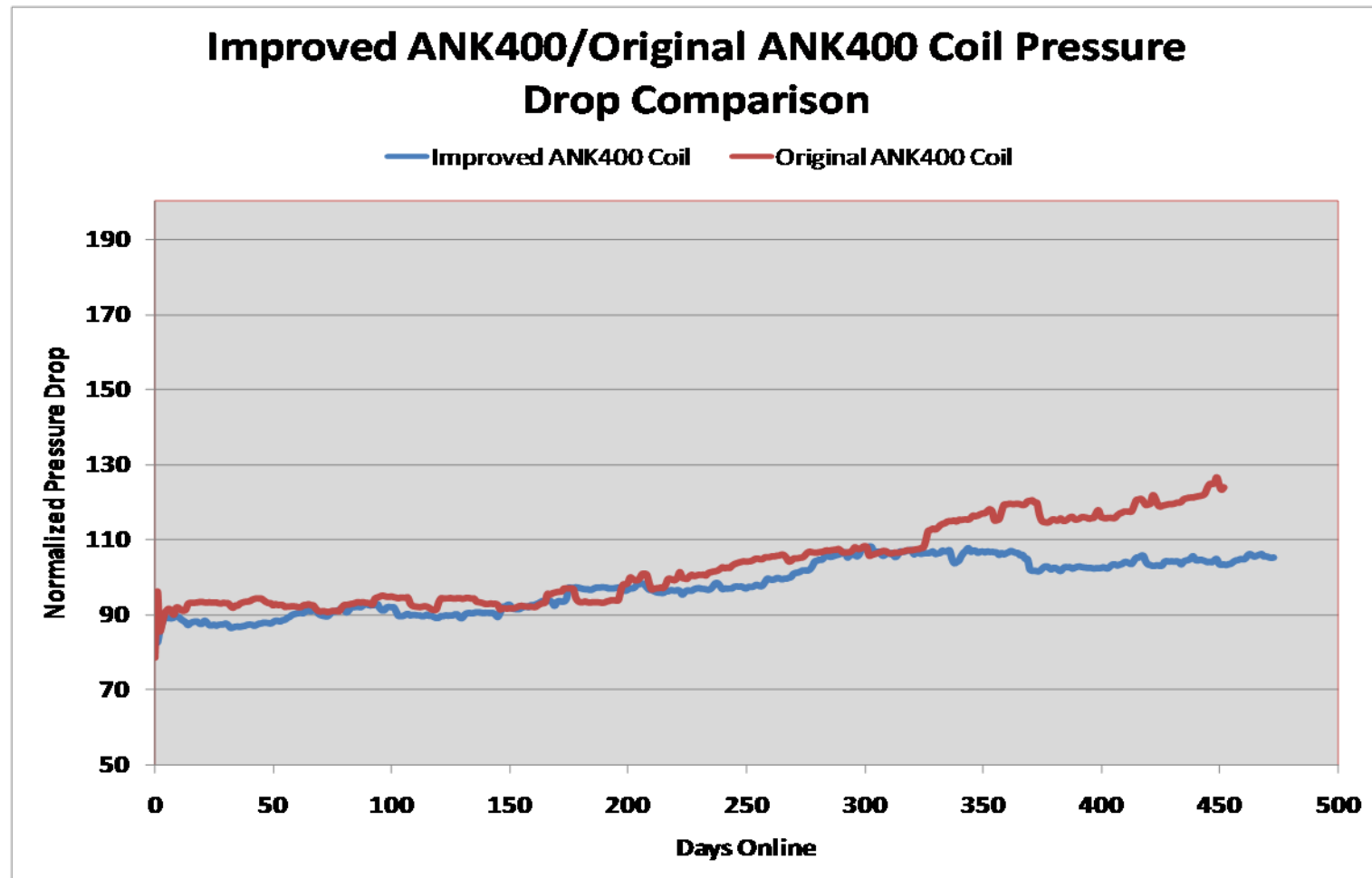


Improvements to ANK400

- Since 2002, NOVA Chemicals and Kubota Metals have been working on improvements to the ANK400 technology.
- Latest improvements to the technology have been in commercial operation since January 2006 demonstrating:
 - ▶ Improved anti-coking performance.
 - ▶ Increased mechanical strength and robustness of the spinel surface.
 - ▶ Increased resistance to thermal shock, creep damage, oxidation, and carburization.
 - ▶ Higher temperature stability allowing broader range of operating applications.

Reduced Coking Rate

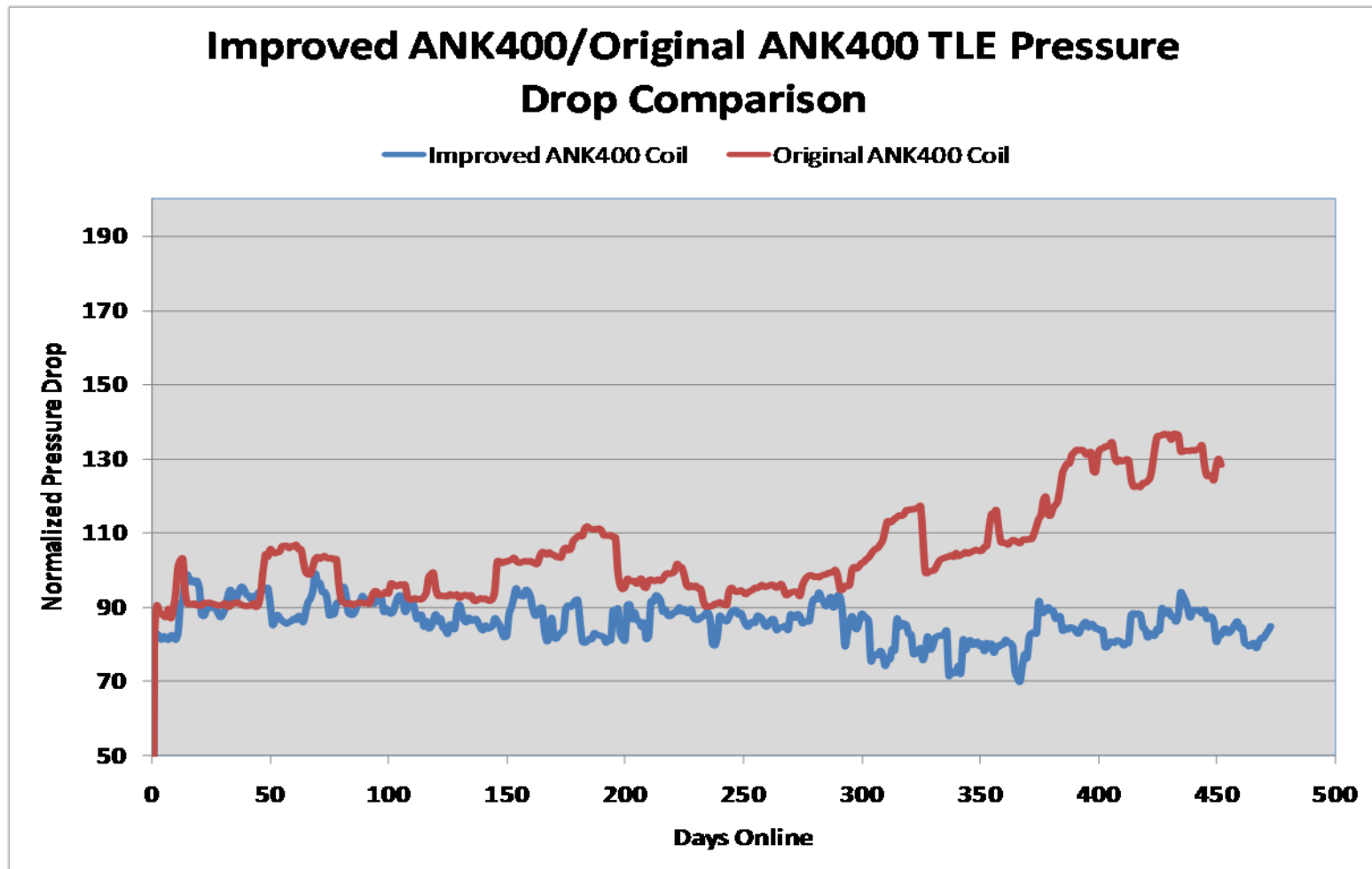
- Reduced coil pressure drop of the improved ANK400(blue) compared to original ANK400(red) performance.





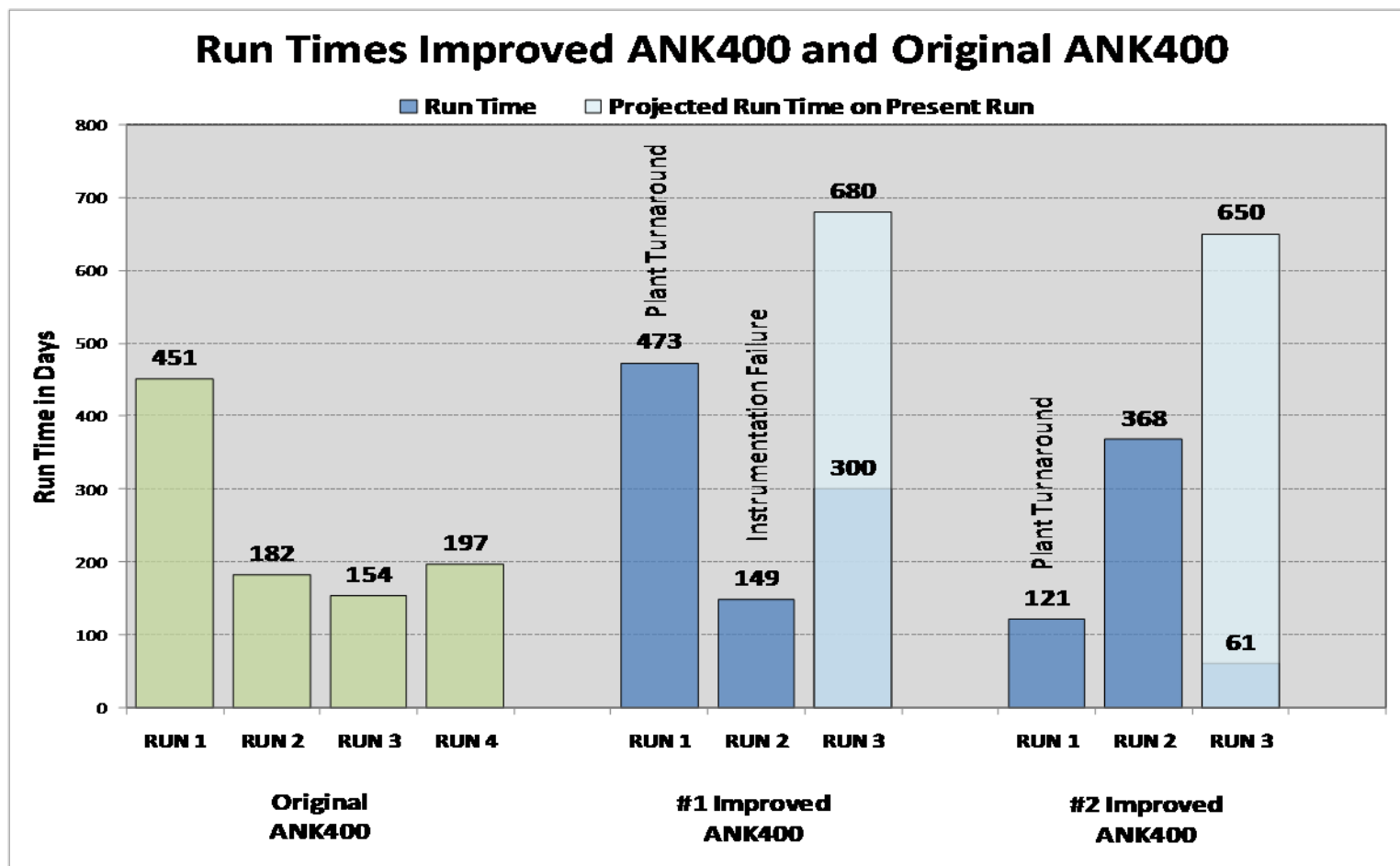
Reduced Coking Rate

- Reduced TLE pressure drop of the improved ANK400(blue) compared to original ANK400(red) performance.



Run-length Improvements

- Run-lengths to date and projected run-lengths for the first two furnaces to use the improved ANK400 are exceeding those of the original ANK400 furnaces.



Conclusion

- ANK400 has already demonstrated ability to significantly reduce coke make.
- Reduction in coking has resulted in real savings in energy and maintenance as well as increased furnace availability and production capability.
- Recent improvements made to the technology are indicating even better performance and promise of additional benefits.
- Performance achieved and continuous learning through applying the technology is inspiring us to continue to strive for an ultimate goal of coke free ethylene furnace operation.

THANK YOU