JM ProcessWise webinar

Benefits of new generation methanol synthesis catalyst in existing methanol plants

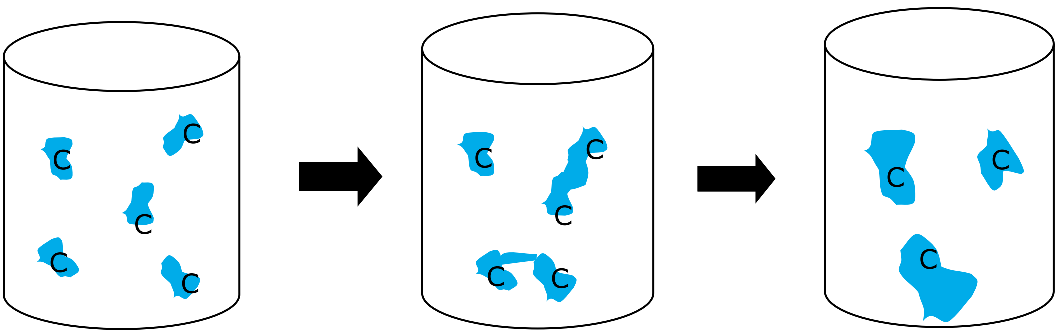
July 2021

Questions and answers

Please note that a number of similar and repeated questions have been combined.

Q1. Could you explain what you mean by thermal sintering?

A1. Thermal sintering is a phenomenon where copper particles and/or atoms migrate and join with other copper particles to make bigger particles but with a smaller surface area.



Q2. Is the basic chemistry of the catalyst the same? Is the new catalyst still CuZn based or is the better performance due to promoters/manufacturing changes?

A2. The new catalyst, **KATALCO** 51-102, is still a copper zinc and alumina-based material for which the formulation has been tailored by adding silica as a stability promoter. This tailored modification to the recipe has no significant impact on other important catalyst performance metrics such as selectivity, strength or attrition resistance, however, the effect on the stability of the catalyst over time is remarkable.

Q3. Is the performances of **KATALCO** 51-102 equivalent to **KATALCO** 51-100 and **KATALCO** 51-101?

A3. **KATALCO** 51-102 has the same initial activity as previous generation catalyst. **KATALCO** 51-102 is the first JM catalyst to include the new silica promoter and so achieves improved stability compared to all previous JM catalysts (including **KATALCO** 51-100/100).

Q4. Would we need to revamp our plant to get the value from the **KATALCO** 51-102 catalyst?

A4. A revamp would not be necessary to get the value from the **KATALCO** 51-102 catalyst. A detailed modelling of **KATALCO** 51-102 vs previous generation catalyst will be done for each catalyst sales prospect to quantify the benefits of **KATALCO** 51-102.

Q5. For a new plant, what type of capex and opex benefits would you expect with this catalyst vs traditional?

A5. The improved activity of **KATALCO** 51-102 increases the cumulative methanol make by approximately 2 % in existing plant designs with both high and low circulation loop designs. The new plant designs could be optimised to reduce the capex by exploiting the benefits of new generation catalyst **KATALCO** 51-102.

Q6. Is the catalyst for use in a specific reactor type? Do we have to make plant or vessel changes for the new catalyst?

A6. **KATALCO** 51-102 is designed to be compatible with as many reactor types as possible. JM will assess any specific needs of each reactor type to ensure the catalyst suitability.

Q7. What is the size and shape of the catalyst, will it have better, or worse pressure drop? Is the new catalyst the same size and shape as the older catalyst?

A7. **KATALCO** 51-102 is same size and shape as **KATALCO** 51-9S with a pellet size of 5.4 mm x 3.6 mm. The expected pressure drop is same as **KATALCO** 51-9S.

Q8. For our reactor the shrinkage is important, how does **KATALCO** 51-102 compare to others?

A8. The shrinkage of **KATALCO** 51-102 is comparable to that of the prior generation catalyst from the 51-series. The addition of silica to the formulation has not impacted the physical properties. Please contact your JM representative for more details; low shrinkage versions of **KATALCO** 51-102 could be available upon request.

Q9. How sensitive is the catalyst to sulphur and Fe poisoning? Comparable to **KATALCO** 51-8?

A9. The new generation methanol synthesis catalyst still copper zinc based and is same as previous generation catalyst. The catalyst is sensitive to sulphur, chloride, iron and nickel carbonyls. Feed purification systems are required to avoid poisoning.

Q10. Are the physical properties of the new catalyst similar or superior to **KATALCO** 51-8 or 9 catalysts? Does **KATALCO** 51-102 have the same bulk density as **KATALCO** 51-8 or **KATALCO** 51-9S? Does the **KATALCO** 51-102 have the same strength as **KATALCO** 51-9S? Is **KATALCO** 51-102 pre-reduced?

A10. Physical properties of **KATALCO** 51-102 is same as **KATALCO** 51-9S. Please request **KATALCO** 51-102 product bulletin from your JM representative for more details.

Q11. Does this catalyst need any special handling for loading?

A11. **KATALCO** 51-102 is supplied in oxidic form. No major changes to handling, loading or reduction is expected.

Q12. Is this catalyst already available and how much does it cost?

A12. The catalyst is already available. Please contact your local JM contact for cost details

Q13. How many references do you have?

A13. There are two operating commercial references, refer to webinar "An update on **KATALCO** 51-102 synthesis catalyst and developments for CO2 to methanol" for more details.

Q14. Are there any side reactions with the new catalyst?

A14. The addition of silica to the formulation has not impacted the formation of by-products. The levels and distribution of by-products formed are equivalent to those expected for the prior generation catalysts from the **KATALCO** 51-series.

The formation of most by-products during the synthesis of methanol is kinetically limited and increase with temperature. Therefore, it is likely that over time the formation of by-products on **KATALCO** 51-102 will be lower due to slower deactivation hence slower ramp-up of temperature.

Q15. Will this change the way JM design their methanol synthesis loops? What impact does this catalyst have for new plants, would there be any changes to the flowsheet?

A15. This new catalyst has the potential to change the way new methanol synthesis loops are designed. However, it will be first observed how first charges of 51-102 performs with existing units before changing the basis for new plants.

Q16. Which deactivation affect normal dominates in normal operation, poisoning or sintering? What are the typical poisons found on MeOH Synthesis Catalyst?

A16. The new generation methanol synthesis catalyst is still copper, zinc and alumina based and is same as previous generation catalyst. The catalyst is sensitive to sulphur, chloride, iron and nickel carbonyls.

Good performance of the feed purification system is required to avoid catalyst deactivation due to poisoning. If the performance of the feed purification system is as expected, the catalyst deactivation should be mainly due to sintering.

Q17. Why high and low circulation rate? what applications for each?

A17. Methanol synthesis is equilibrium limited. To maximise the conversion a circulating loop is required with reactor effluent recycle. Purge stream controls the inert built-up and loop gas composition.

The high circulation loops will have a circulation ratio of 6 and methanol of approximately 5 mole % in the effluent. The low circulation loops will have a circulation ratio of 2 and methanol of approximately 11 mole % in the effluent.

When the catalyst ages, the activity drops due to thermal sintering. To counter-act the impact of the drop-in activity the converter average operating temperature is usually increased. This tends to increase the equilibrium temperature about 25°C from 0 to 4 years of lifetime.

At 5% MeOH exit the converter the loop efficiency changes from 98% to 94 % with 25°C equilibrium temperature rise, corresponding to a 1% efficiency loss for every 6 °C equilibrium temperature rise.

At 11% MeOH exit the converter the loop efficiency changes from 97% to 89% with 25°C equilibrium temperature rise. Corresponding to a 2% efficiency loss for every 6 °C equilibrium temperature rise.

The commercial impact of reducing the loop efficiency by 8% (rather than 4%) from BOL to EOL means that the low recycle loop tends to replace catalyst more frequently than the high recycle flow loop.

JM designs methanol synthesis loop with high circulation and usually with a radial steam rising converter. The radial flow allows for a low pressure drop (the lowest of any type of converter) with only a marginal increase in pressure drop as the catalyst ages. The low pressure drop through the converter allows for a higher recycle flow for a given circulator power. Therefore, the converter achieves higher conversions and does not require high catalyst activity at end of life, when compared to operating with a low recycle and a low converter exit temperature.

Installing JM new generation synthesis catalyst KATALCO 51-102 allows the high circulation loops to operate with a lifetime of 8 years and with stable carbon efficiency throughout the lifetime.

Q18. If loop efficiency with new catalyst is better than standard catalyst even with 2 charges over 8 years, what stops us using this new catalyst for more than 8 years?

A17. **KATALCO** 51-102 is the first JM catalyst to include the new silica promoter and so achieves improved stability compared to all previous JM catalysts. The improved thermal stability of the catalyst reduces the deactivation due to thermal sintering. Albeit **KATALCO** 51-102 is still copper, zinc and alumina based is sensitive to sulphur, chloride, iron and nickel carbonyl poisoning.

Q19. To get the benefit of the new catalyst, would we need to operate at the same or different temperatures and pressures?

A19. **KATALCO** 51-102 has the same initial activity as the previous generation catalyst. The improved thermal stability achieved with silica doping reduces the catalyst deactivation due to thermal sintering. Due to slower deactivation it is expected that **KATALCO** 51-102 will operate at a reduced temperature than previous generation catalyst for the same lifetime. JM does not foresee a change in operating pressure of the plant with **KATALCO** 51-102.

Q20. You mentioned that sintering properties of this catalyst is better than the older type, how does it compare for poison resistance

A20. The small change to the formulation in **KATALCO** 51-102 has not impacted the resistance to poisons of the catalyst. The existing purification section of the plant should still be sufficient when operating with **KATALCO** 51-102.

Q21. Is this process something competitors like Topsoe or Clariant are working on as well?

A21. JM is not aware of any equivalent product on the market.

Q22. What is 100% carbon efficiency?

A22. Loop carbon efficiency is defined as methanol in the crude methanol product divided by sum carbon monoxide (CO) and carbon dioxide (CO_2) in the makeup gas on molar basis

For a 100% carbon efficiency, (CH_3OH mole % in crude) / (CO + CO_2 mole % in MUG) = 1.