



Replacement of Chlorinated Paraffins in Heavy-duty Metalworking Processes

Wilhelm Rehbein; LANXESS Deutschland GmbH, Cologne, Germany
ILMA 6th International Metalworking Fluids Conference, January 8-10, 2024; Atlanta, GA, USA

Agenda

- Sulfur carriers and chlorinated paraffins
– technical and H&S aspects
- Sulfur carriers definition
- Function of EP additives
- Thread forming and thread cutting test results
- Summary and conclusion



Comparison of EP-Additives, technical Aspects

Chlorinated Paraffins

- Effective EP-additives at low machining speeds
- Thermal decomposition at higher machining speeds and temperatures leads to increased tool wear
- Hydrolysis in presence of moisture, formation of hydrochloric acid
- Compatible with most MWF additives
- Colorless and odorless
- Low costs but high disposal costs in some regions

Sulfur Carriers

- Sulfur carriers with different activities and polarities available
- Outstanding efficiency over a broad temperature range
- Performance can be even increased by using synergistic combinations with other additives
- Support fast chip breaking, prevent formation of long chips
- Compatible with most MWF additives
- Light color and low odor
- Standard waste oil treatment, no additional requirements on disposal

Comparison of EP-Additives, H&S Aspects

Chlorinated Paraffins

- Short chain chlorinated paraffins (SCCPs) banned in many countries – persistent, bioaccumulative and suspect of causing cancer
- Intentions to ban or restrict the use of medium chain chlorinated paraffins (MCCPs) by e.g. the ECHA, the Japanese and South Korean Ministries of Environment and by the UN Environment Program
- Discussions about a ban of MCCPs and long chain chlorinated paraffins (LCCPs) in the US
- Chlorinated paraffins are GHS categorized as “very toxic to aquatic organisms with long lasting effects”

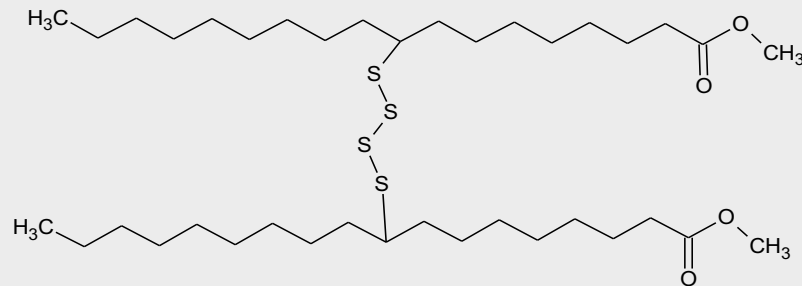
Sulfur Carriers

- No hazard classification
- Many sulfur carriers are based on renewable raw materials
- Some sulfur carriers are 100% biodegradable and nontoxic to aquatic life
- Some sulfur carriers are suitable formulation components for EU Ecolabel and US VIDA compliant formulations
- Many sulfur carriers can be certified as having low or no impact on the environment and showing no health hazards

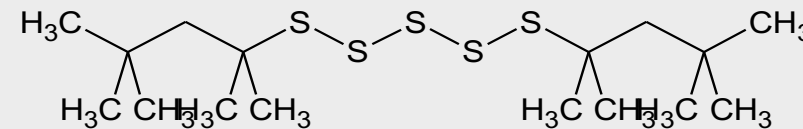
What are Sulfur Carriers?

“Sulfur Carriers”

- Are made from olefins, natural oils or synthetic esters
- Contain 2 to 5 sulfur atoms forming a “bridge” between the olefin or ester parts
- Have polar centers to adsorb on metal surfaces
- Make sulfur oil-soluble and able to form protective layers
- Work perfectly as EP additives in metalworking processes
- Are excellent replacements for chlorinated paraffins

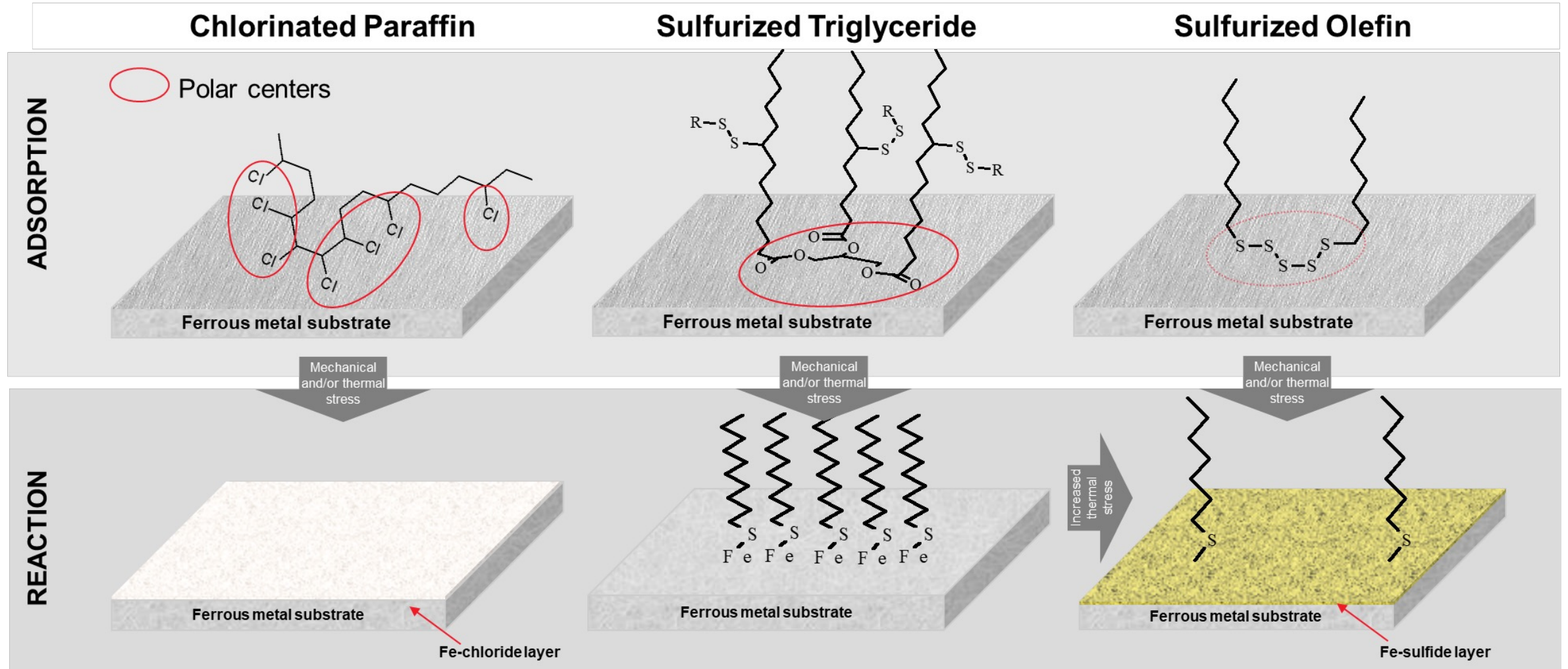


Sulfurized methylester



Sulfurized olefin

Formation of Adsorption and Reaction Layers by EP-Additives



Thread Forming and Thread Cutting Test Results

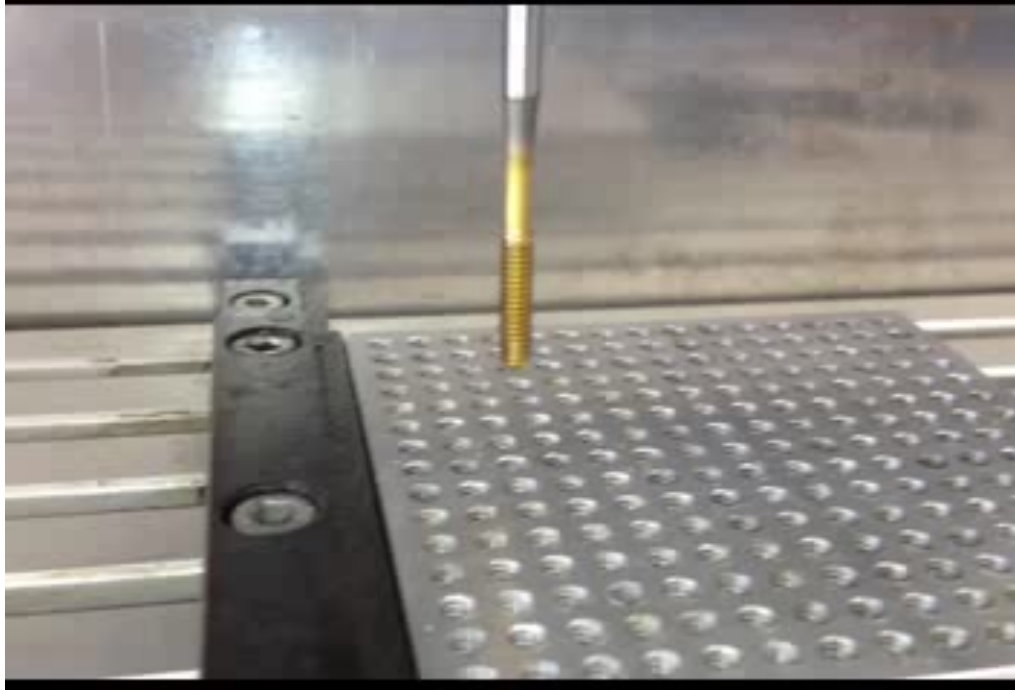


Tapping Torque Test



- Real thread cutting or thread forming process
- Can be done with many different workpiece materials and tools
- Transferable to real metalworking processes
- Torque is recorded and used for evaluation of MWF

Thread forming in stainless steel

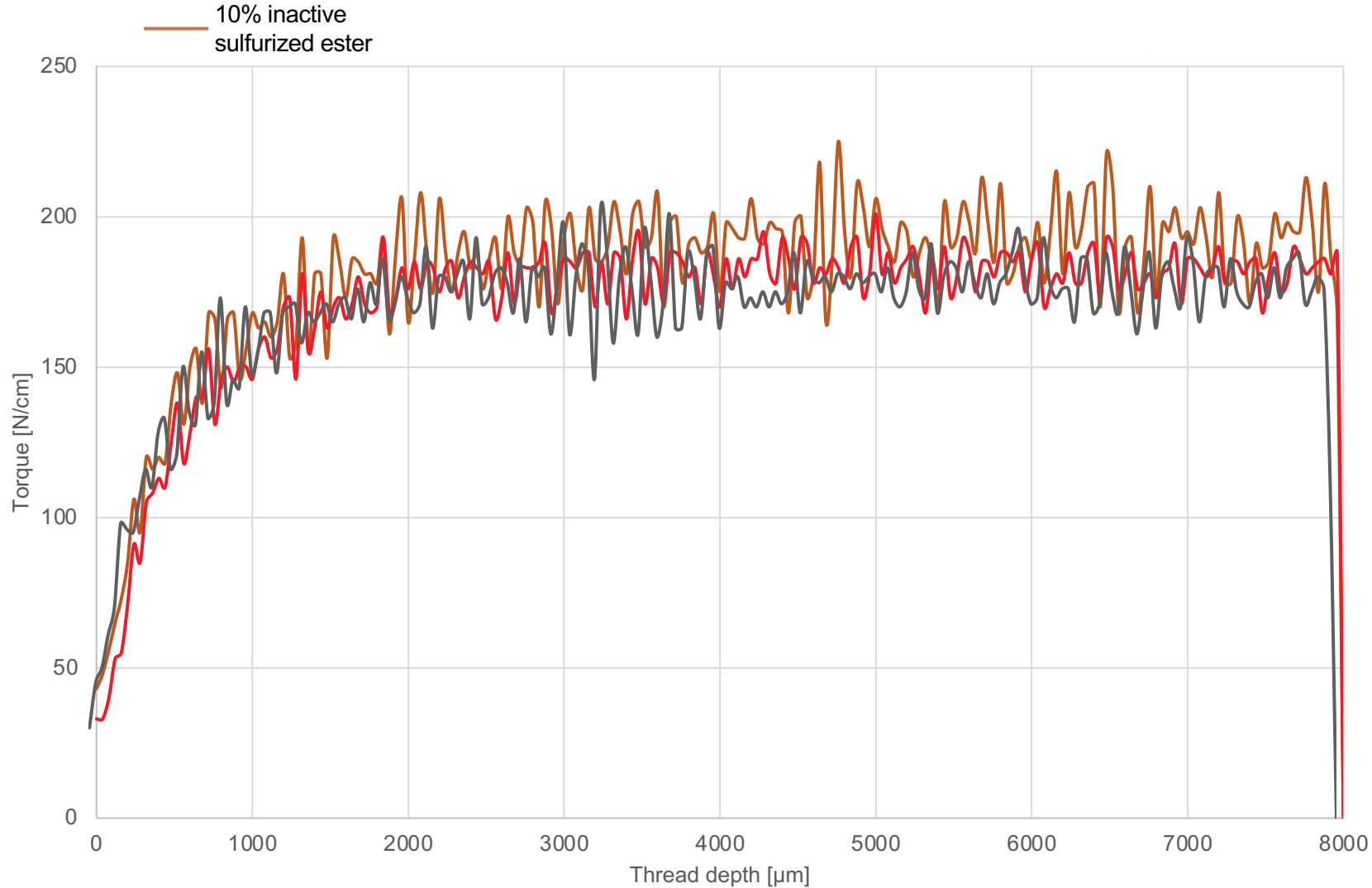


Forming an internal thread

- Material:
 - Stainless steel AISI 316 (V4A; X2CrNiMo17-12-2)
- Core hole diameter 3.7 mm
- Thread forming tool: M4, TiAlN-coated
- Depth of thread 8 mm
- Speed 800 rpm
- Base oil: Grp. I, ISO VG 46
- Repeatability: < 5% deviation from average value
- Mixed friction and boundary friction conditions

Thread Forming

Influence of Viscosity

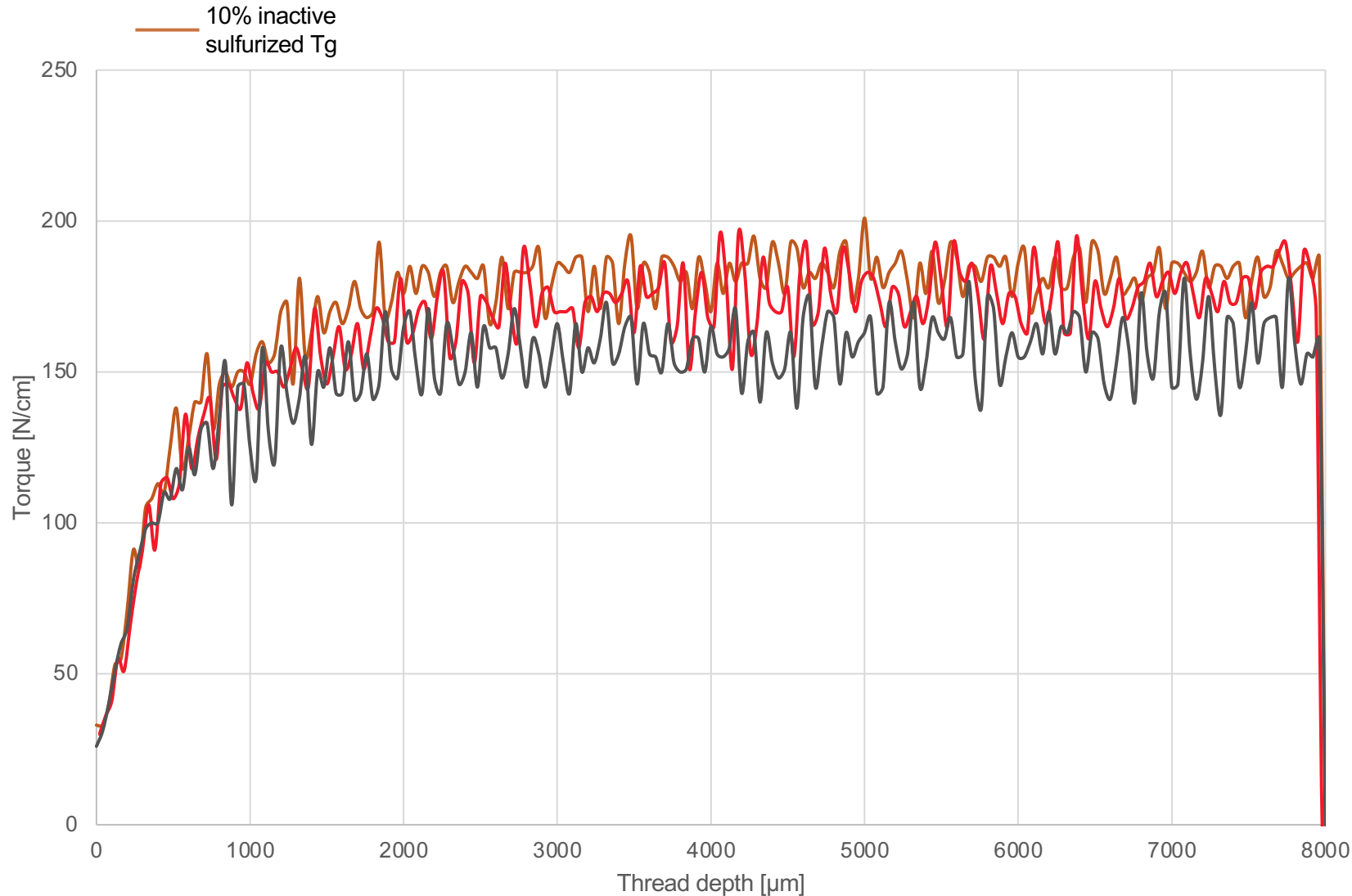


Thread forming, AISI 316 (V4A)

	Kin. Viscosity at 104°F (40°C) [cSt]	Average torque [N/cm]
10% inactive sulfurized ester, 10% S	30	190

Thread Forming

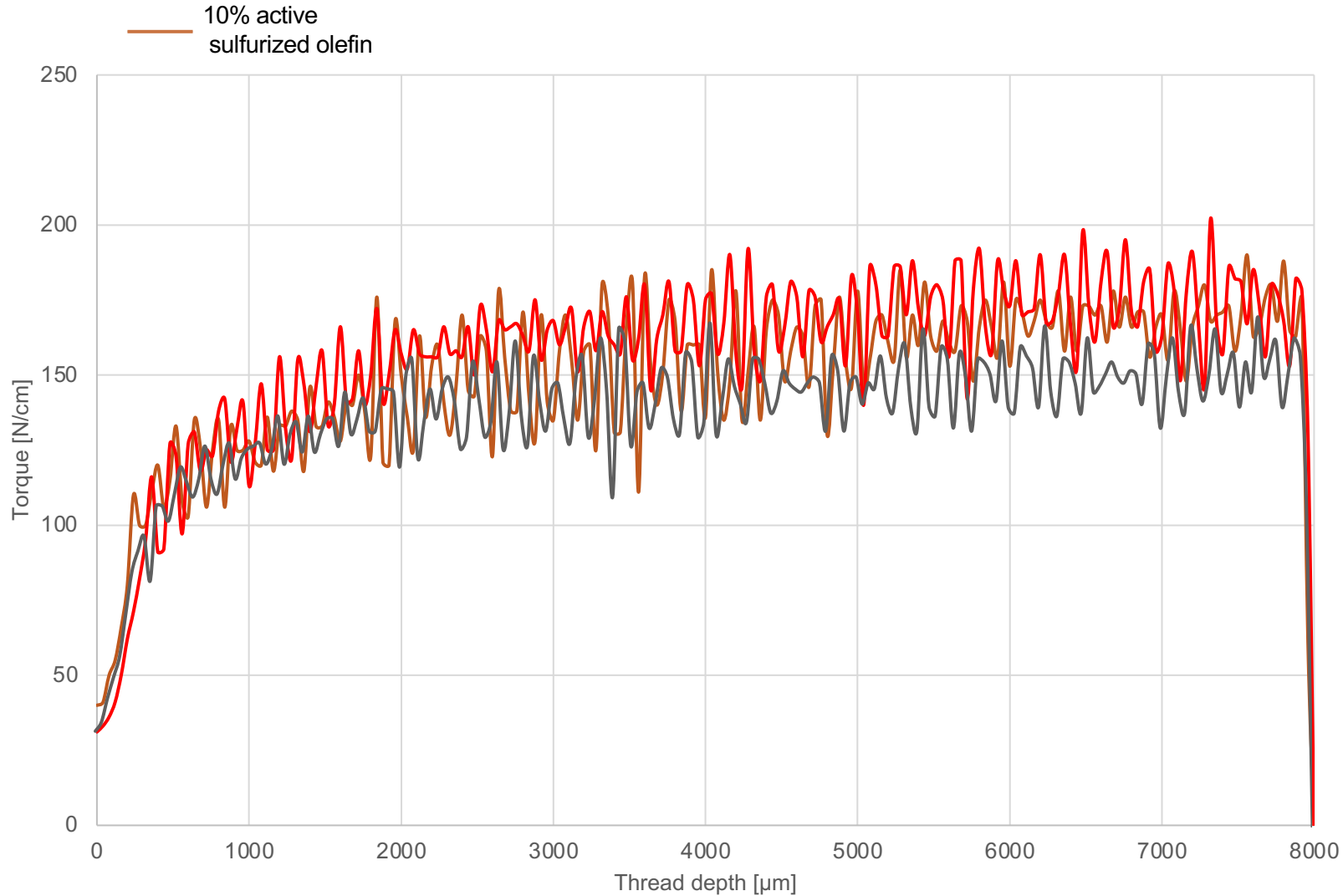
Influence of Sulfur Content / Activity



Thread forming, AISI 316 (V4A)

	Average torque [N/cm]	Max. torque [N/cm]
10% inactive sulfurized Tg, 10% S	180	201

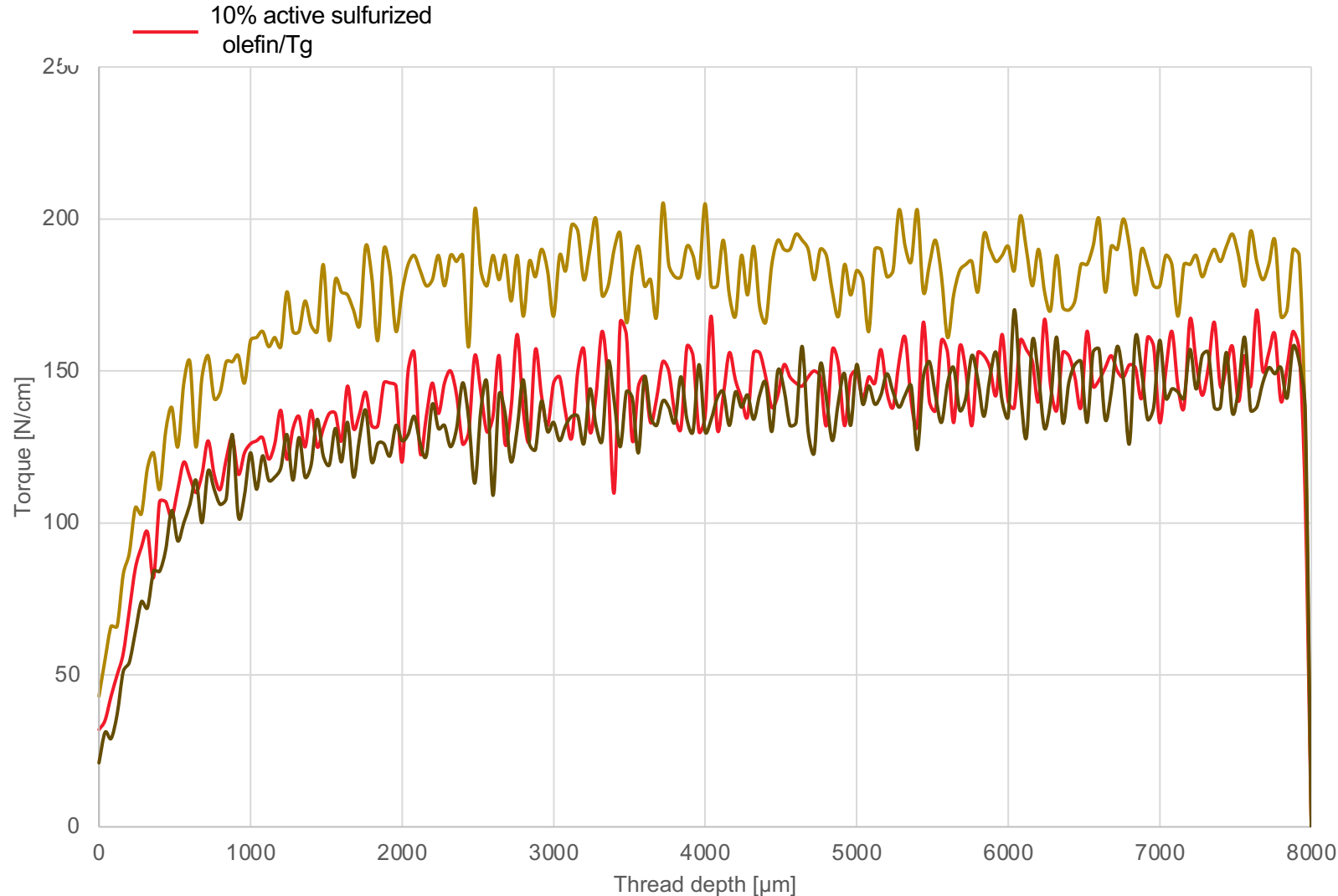
Thread Forming Sulfurized olefin



Thread forming, AISI 316 (V4A)

	Average torque [N/cm]	Max. torque [N/cm]
10% active sulfurized olefin, 40% S	157	190

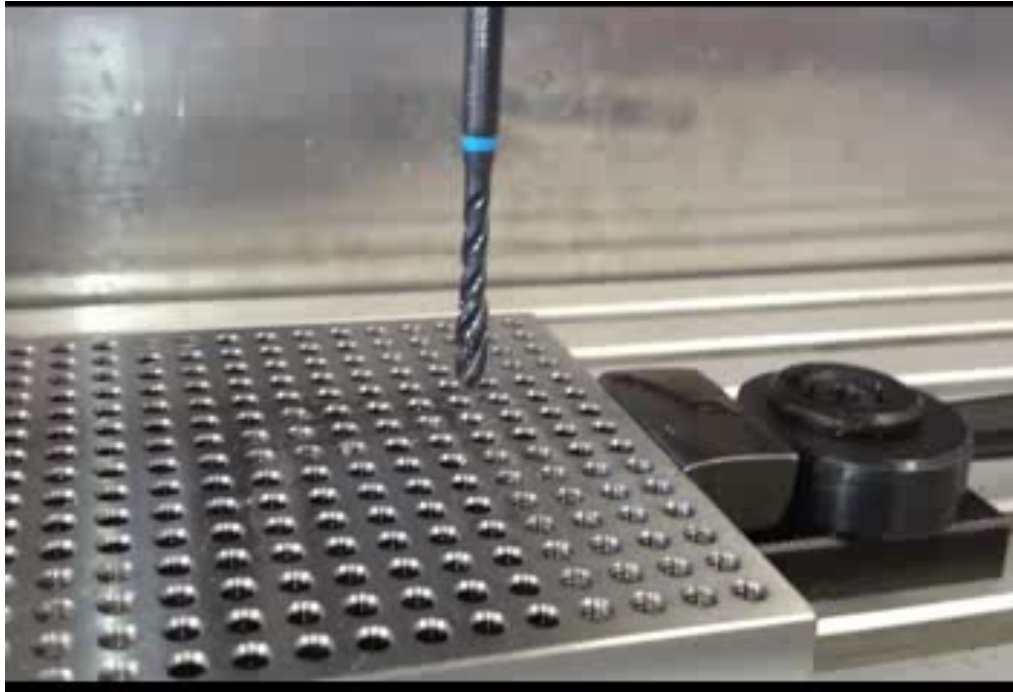
Thread Forming Comparison with Chlorinated Paraffin



Thread forming, AISI 316 (V4A)

	Average torque [N/cm]	Max. torque [N/cm]
10% active sulfurized olefin/Tg, 26% S	145	170

Thread cutting in stainless steel

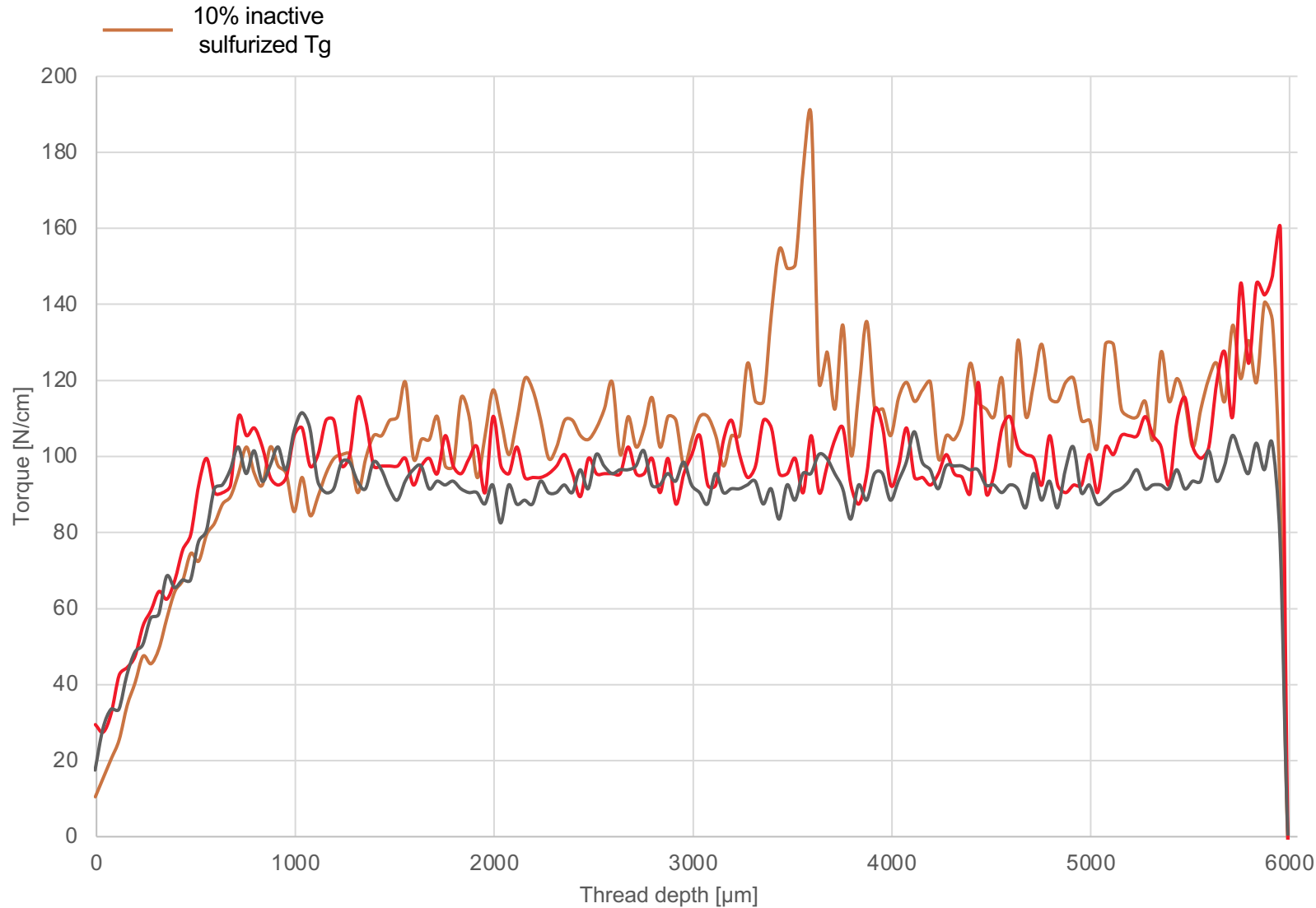


Cutting an internal thread

- Material:
 - Stainless steel AISI 316 (V4A; X2CrNiMo17-12-2)
- Core hole diameter 3.3 mm
- Thread cutting tool: M4, non coated
- Depth of thread 6 mm
- Speed 800 rpm
- Base oil: Grp. I, ISO VG 46
- Repeatability: < 5% deviation from average value
- Mixed friction and boundary friction conditions

Thread Cutting

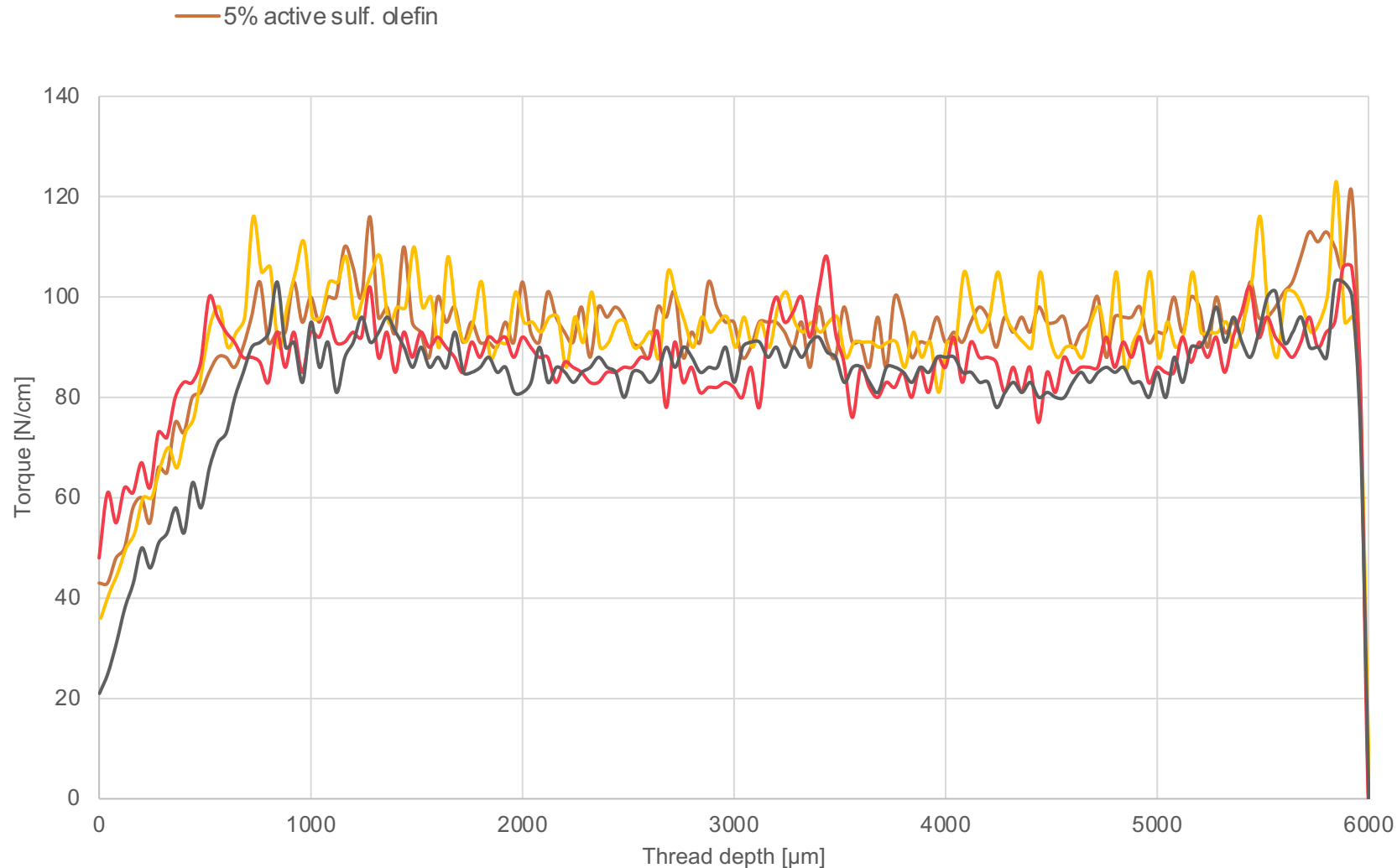
Influence of Sulfur Content / Activity



Thread cutting, AISI 316 (V4A)

	Average torque [N/cm]	Max. torque [N/cm]
10% inactive sulfurized triglyceride, 10% S	114	190

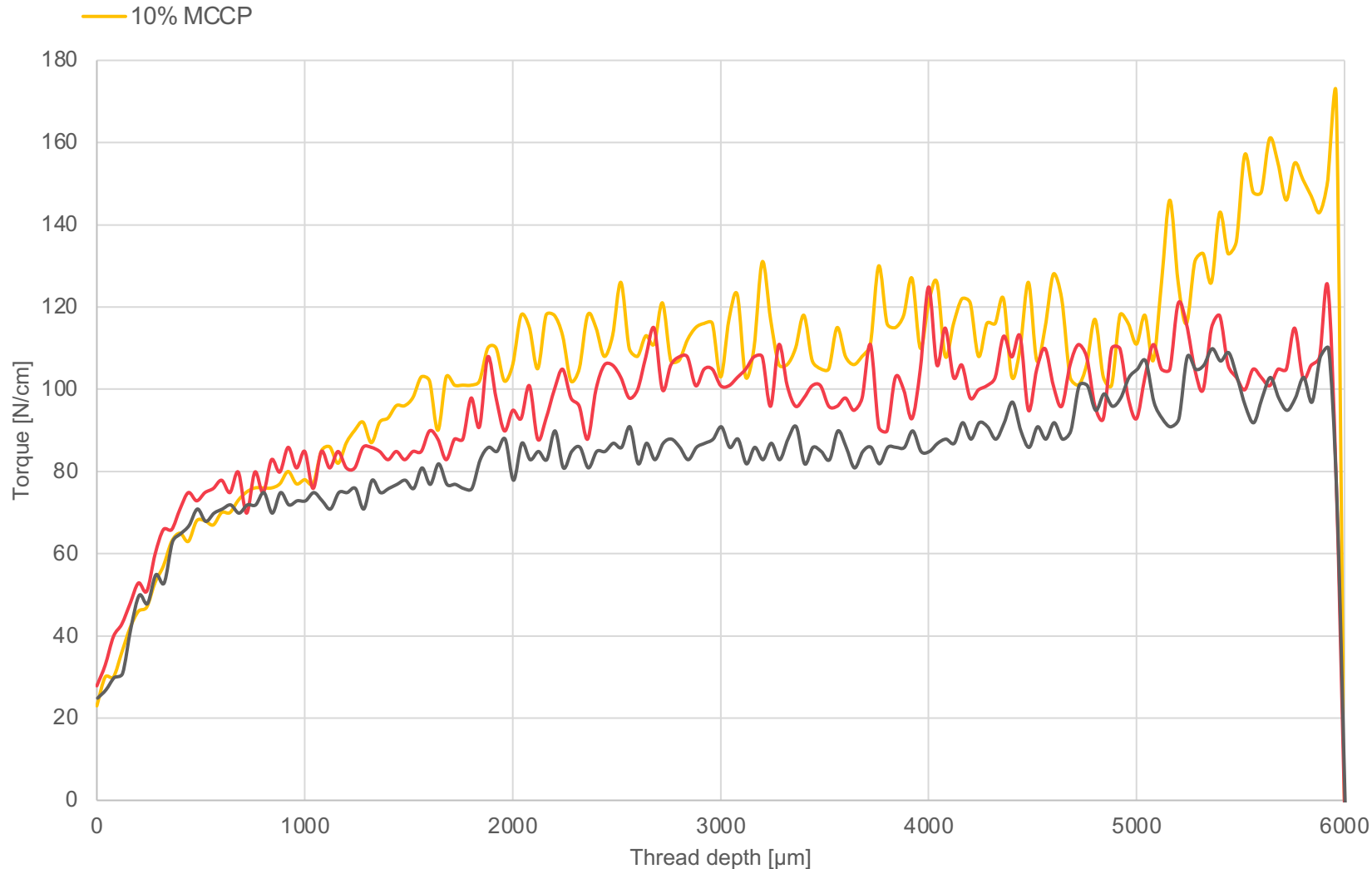
Thread Cutting Formulations with high Sulfur Content / Activity



Thread cutting, AISI 316 (V4A)

	Average torque [N/cm]	Max. torque [N/cm]
5% active sulfurized olefin, 40% S	96	116

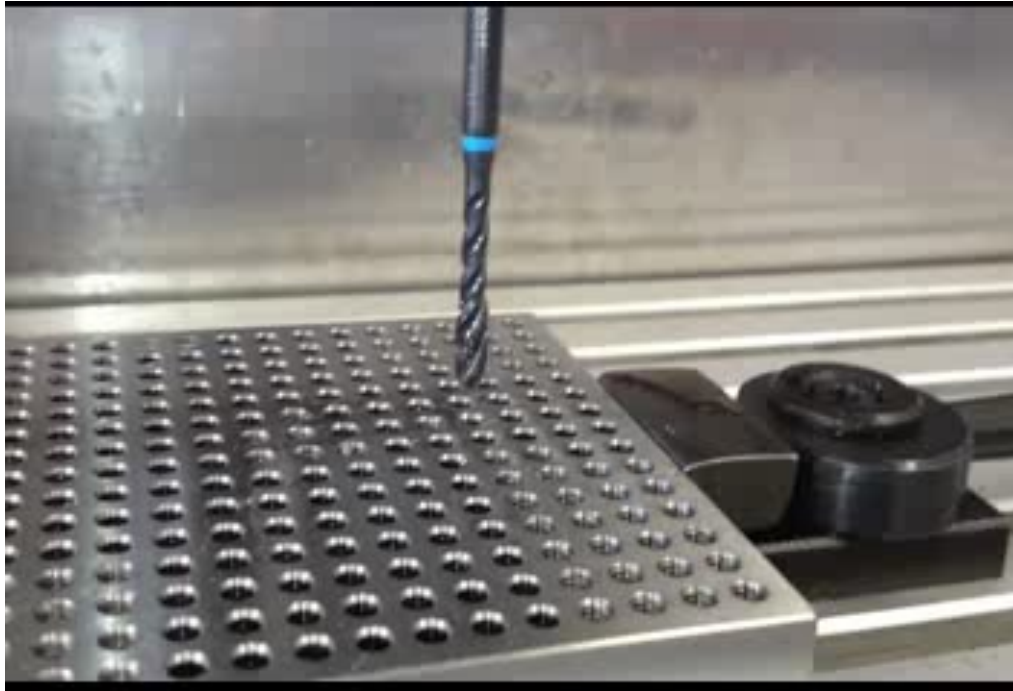
Thread Cutting TiN-coated Cutting Tools



Thread cutting, AISI 316 (V4A)

	Average torque [N/cm]	Max. torque [N/cm]
10% medium chain chlorinated paraffin, 50% Cl	114	161

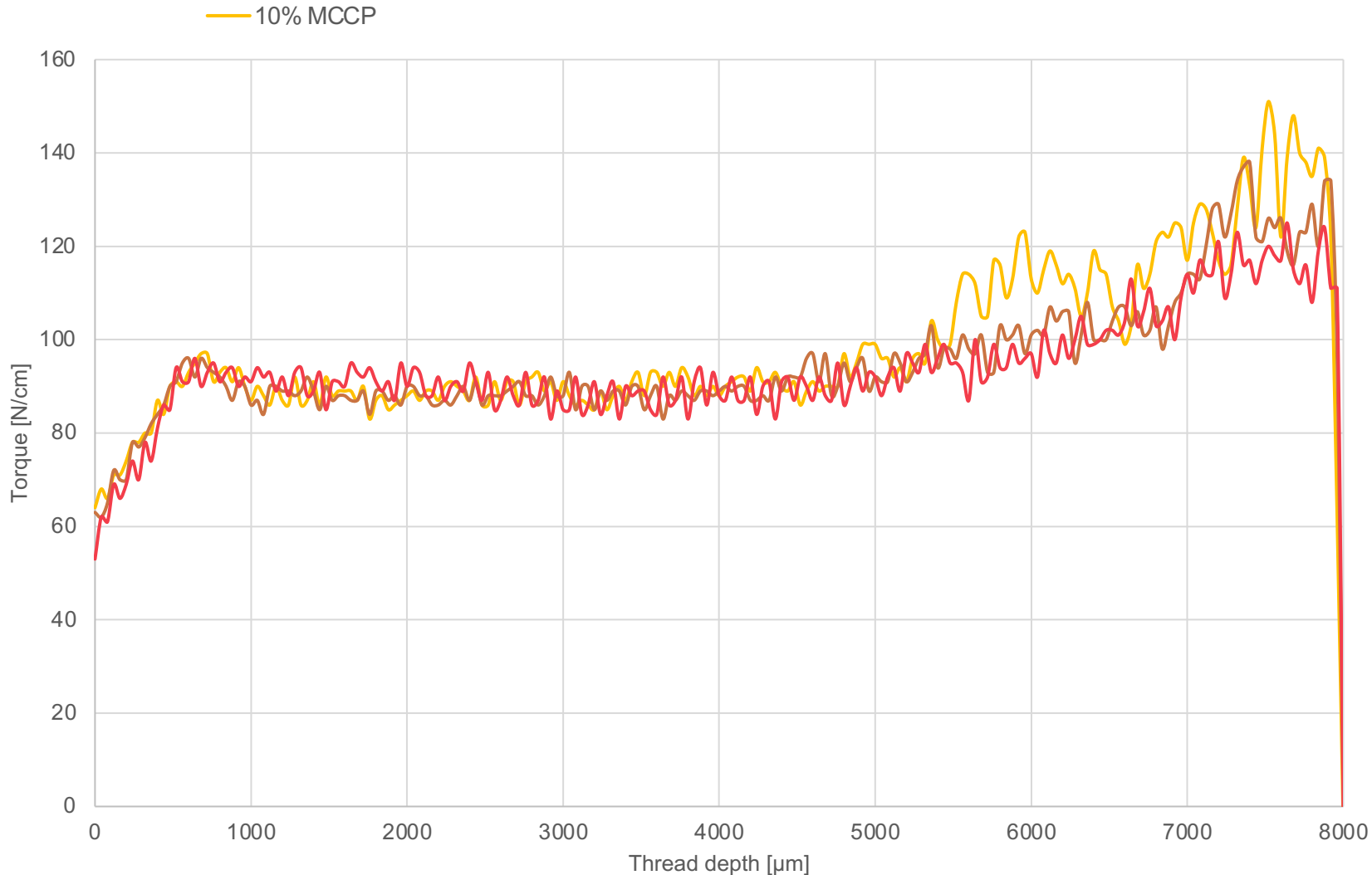
Thread cutting in high alloyed steel



Cutting an internal thread

- Material:
 - High alloyed steel AISI 4140 (42CrMo4)
- Core hole diameter 3.3 mm
- Thread cutting tool: M4, non coated
- Depth of thread 8 mm
- Speed 1000 rpm
- Base oil: Grp. I, ISO VG 46
- Repeatability: < 5% deviation from average value
- Mixed friction and boundary friction conditions

Thread Cutting High Alloyed Steel



Thread cutting, AISI 4140

	Average torque [N/cm]	Max. torque [N/cm]
10% medium chain chlorinated paraffin, 50% Cl	101	151

Summary and Conclusions

- Tapping Torque test results demonstrate that sulfur carriers are excellent replacements for chlorinated paraffins when thread cutting or thread forming stainless steels and high alloyed steels
- The lower torques indicate
 - lower energy consumption in the machining process
 - lower mechanical stress for the tool which results in longer tool life
- Sulfur carriers show clear advantages compared to other types of EP additives:
 - Effectively decrease adhesive and abrasive wear
 - Significantly lower environmental impact
 - Non-hazardous to humans and to the environment
- By combining suitable sulfur carriers and other lubricant additives it is possible to even exceed the performance of chlorinated paraffin containing cutting and forming lubricants

LANXESS has expanded its capacity on EP additives and offers technical expertise and support for the development of CLP-free metalworking fluid formulations with superior performance characteristics

LANXESS

Energizing Chemistry

Disclaimer

PRODUCT SAFETY INFORMATION REQUIRED FOR SAFE USE OF PRODUCTS MENTIONED HEREIN IS NOT INCLUDED IN THIS DOCUMENT. BEFORE HANDLING ANY PRODUCT, READ PRODUCT AND SAFETY DATA SHEETS AND CONTAINER LABELS FOR SAFE USE, PHYSICAL AND HEALTH HAZARD INFORMATION.

- The information and data referred to in the foregoing presentation: (a) is intended for technical consideration only; (b) is given in good faith and believed to be accurate, but we do not represent, warrant, or otherwise guarantee, expressly or impliedly, the merchantability, fitness for a particular purpose, freedom from patent infringement, suitability, accuracy, reliability, or completeness of this information or the products, materials, processes and advice described herein; (c) do not, and are not intended to be an endorsement of any product or process not manufactured by LANXESS, nor the specifications or performance of any such products, and we expressly disclaim any contrary implication; and (d) should not be relied upon in connection with selection of products for use in specific applications.
- Unless specified to the contrary, the values given have been established on standardized test specimens and refer exclusively to the specimens tested. The figures should be regarded as guide values only and not as binding minimum values. Under certain conditions, the test results established can be affected to a considerable extent by the processing conditions and manufacturing process.
- WE EXPRESSLY DISCLAIM LIABILITY FOR ANY LOSS, DAMAGE OR INJURY DIRECTLY OR INDIRECTLY SUFFERED OR INCURRED AS A RESULT OF OR RELATED TO ANYONE USING OR RELYING ON ANY OF THE INFORMATION AND DATA IN THIS PRESENTATION.
- ©2023 LANXESS Additin®, Lobase®, Durad®, Reolube®, Royco®, Anderol®, Everest®, Naugalube®, Hybase®, Synton®, Hatcol®, LANXESS and the LANXESS Logo are trademarks of LANXESS Deutschland GmbH or its affiliates. The trademarks are registered in many countries in the world. This document may not be distributed, displayed, copied or altered without the prior expressed written authorization by LANXESS. To the extent LANXESS does authorize distributing, displaying and/or copying of this document, such consent shall be conditioned upon use of the document unaltered and complete, including all of its headers, footers, disclaimers and other information. You may not copy this document to or reproduce it in whole or in part on a website or social media account.