The importance of tribology in climate discussions and for sustainability goals

-Studies of the German Society for Tribology-

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Tribology and lubrication sciences offer hidden contributions to save GHG emissions downstream (use phase). Taking friction reduction and longevity together, the medium/long-term reduction potentials through tribology amount to 3.7-10.6 gigatons of $CO_{2eq.}$. Energy not consumed downstream and saved resources from longevity of goods achieved downstream not must be generated or produced upstream, what is equivalent to significant CO_{2eq} savings. Tribology and lubrication sciences shall be considered as carbon dioxide removal sinks and compete by GHG savings with other carbon dioxide removal sinks or negative emission technology.

Keywords: negative emissions technology, carbon dioxide removal, friction, longevity, tribology, CO_2, GHG

1. Introduction

In the public discussion and perception, the resource consumption has so far been subordinate to the CO_2 targets. Tribology is an interdisciplinary key technology for closing the CO_2 gap by 2040 to 2060. The cause-root relationship between friction and CO_2 emissions as well as between durability/longevity and sustainability so far didn´t reach politics and society. Friction reductions can help to save 8-13% of primary energy in the medium term or 2.7-4.4 gigatons of CO_2 p.a. [1,2], while longevity through wear protection and condition monitoring can save 1.7 to >4.6 gigatons of CO_{2eq} p.a. as indirect contribution to reducing CO_2 Emissions [3,4]. The extraction of resources and their further processing is inevitably associated with CO_2 emissions. A hypothetical doubling of the general service life through wear protection and condition monitoring saves approx. >9.0 gigatons of resources per year combined with an equivalent of 1.39-1.86 ton of CO_{2eq} per ton of resource. These considerations are oriented on the sustainable development goals of United Nations. Friction and wear occur everywhere and anytime along the value chain. Friction reduction and longevity must be seen as "negative emissions technologies" (NET) of downstream (scope 4 "avoided emissions") with high implementation potential or technology readiness levels (TRL).

Friction reduction and longevity are "industrial carbon removal" or "societal carbon removal" technologies, because $CO_{2eq.}$ savings by tribology occurs everywhere and anytime. Friction reduction and longevity must be seen as "negative emissions technologies" (NET) of downstream, because they create less or save CO_2 during operation or are easy-to-avoid emissions as a drop-in solution, which not needs to be generated upstream. Energy not consumed downstream in the use phase not needs to be produced upstream.

From a socio-ecological perspective, friction reduction and longevity help to double the utility value while consuming the same amount of resources resulting in an overall reduction in $CO_{2eq.}$ and GHG emissions.

2. Pathways for Carbon Dioxide Capture and Storage

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Table 1: Estimated mitigations potentials of response options for carbon dioxide removal [6]

Carbon dioxide removal sinks	Mitigation potential until 2050 [gigatons CO_2/yr.]	
	Min.	Max.
Enhanced weathering	0.5	4.0
Afforestation/reforestation	0.5	10.1
Soil carbon sequestration in croplands and grasslands	0.4	9.3
Friction reduction	2.0	4.4
Longevity* of engineering materials	>1.7	>4.6
Geological sequestration		10.0

***$CO_{2eq.}$**

3. Avoided Emissions (Scope 4)

The technical guideline for scope 3, category 11, "Scope 3, category 11, "Use of sold products", requires only reporting from the use phase of sold (complete) products, like for vehicles. The GHG protocol not deals with savings, but only with reporting. Around 80±5% of cradle-to-grave emissions for road vehicles were emitted during the use phase by combusting fossil fuels or in the case of electric/hybrid drivetrains from electricity generation.

The term "avoided emissions" (scope 4) appeared first in 2013 in a commentary by the World Resources Institute in November 2013 [7] to the fifth assessment report of Intergovernmental Panel on Climate Change (IPCC). The proposed definition was:

> "Emission reductions that occur outside of a product's life cycle or value chain, but as a result of the use of that product. Examples of products (goods and services) that avoid emissions include fuel-saving tires, energy-efficient ball-bearings, etc.".

Many perceive, that technological approaches for carbon removal remain at the earliest stages of development as well as require hughe investments and drastic cost reductions to make them affordable. Mature tribological tools and technologies at a technology readiness level (TRL) of >6 are right the way available and just need to be applied.

4. Summary

The growth in human population and its wealth have significant implications for our resource demands on Nature, including for future patterns of global consumption. If we are to avoid exceeding the limits of what Nature can provide while meeting the needs of the human population, consumption and production patterns must be fundamentally re-structured as well. Here comes the offers of tribology into play through longevity (resource efficiency and resource conservation) and friction reduction (energy efficiency). Longevity, either by wear protection or by condition monitoring, extends the use phase of goods and assets, which reduces the extraction of natural resources as well as complies with material efficiency and resource conservation. Friction, as an irreversible loss, is proportional to carbon dioxide emissions. Energy saved downstream by friction reduction must not be generated upstream!

Friction and wear occur everywhere and anytime along the value chain. Measures to reduce friction and extend longevity must be included in the emissions trading system. Tribology must become allocable for CO_2 certificates.

5. References

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