Óbudai Egyetem

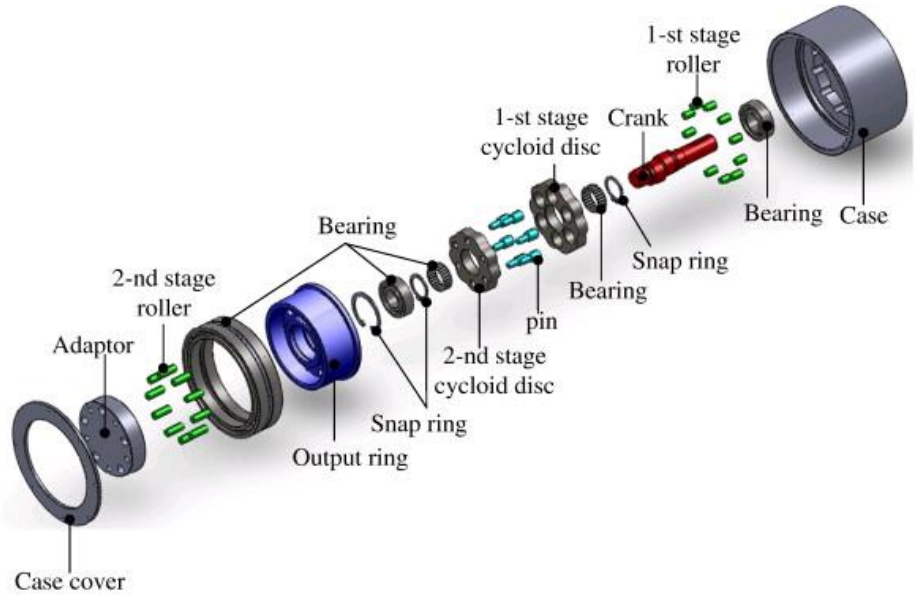
Tribological properties of carbon nanofillers added Si_3N_4 composites – A Review

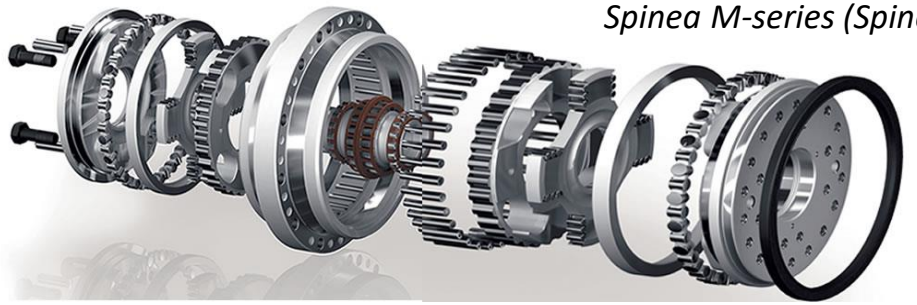
Awais Qadir

Supervisor: Prof. Dr. Ján Dusza,
Dr. Pinke Peter

PROBLEMS IN METALLIC BASED BEARINGS (GEAR BOX)

- Heavy and noisy
- Lack of chemical resistance (depending on the grade of steel)
- Require constant lubrication (high maintenance cost)
- Susceptible to corrosion in humid or wet environments
- May cause problems in medical applications due to its magnetic properties
- High friction coefficients (COF)
- High Coefficient of Thermal Expansion (CTE)
- High temperature oxidation

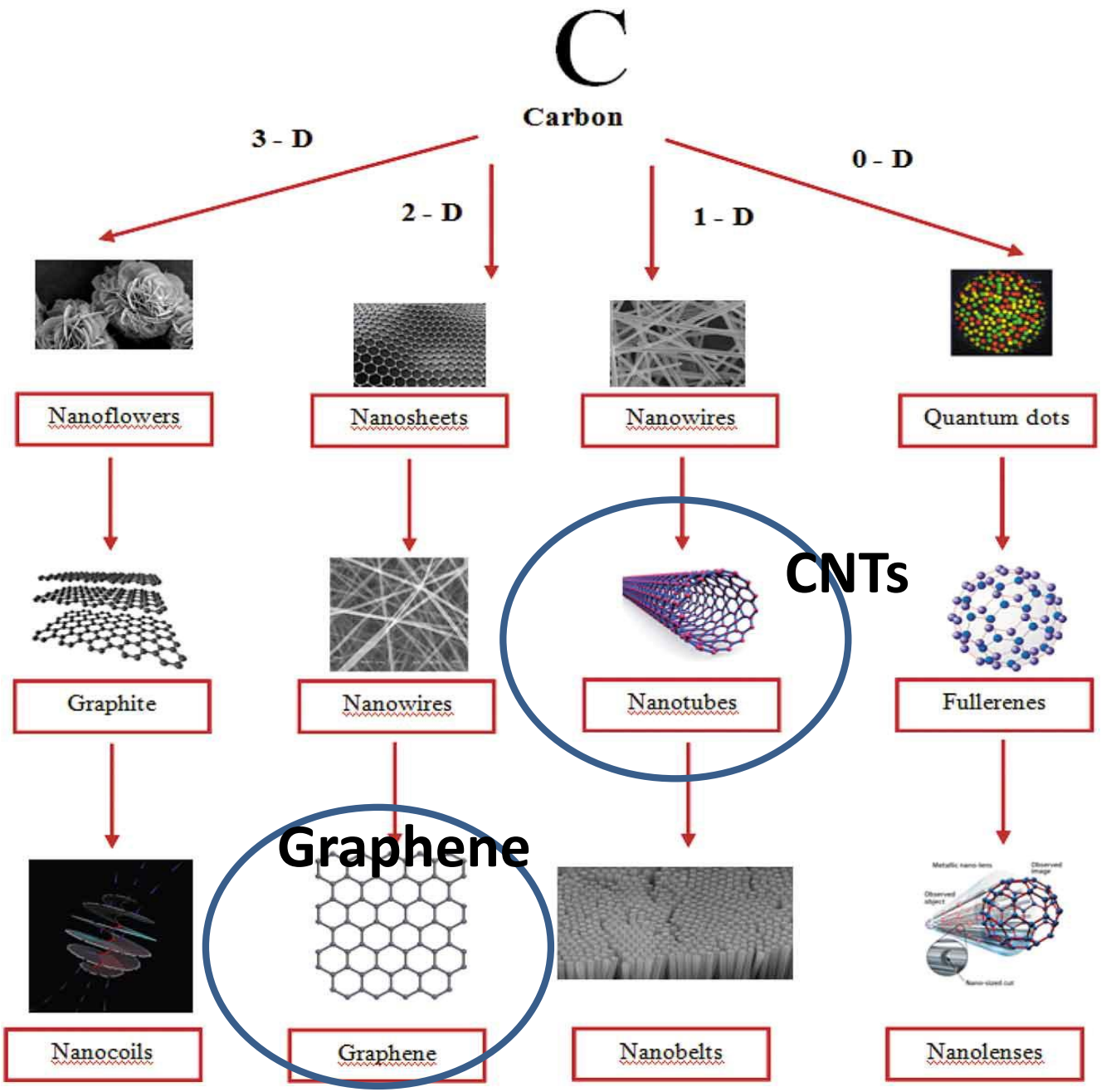




Spinea M-series (Spinea s.r.o)

Semester Progress Report Jan - 2020, Obuda University

Carbon Derived Structures



Why Si_3N_4 + Carbon nanofillers composites?

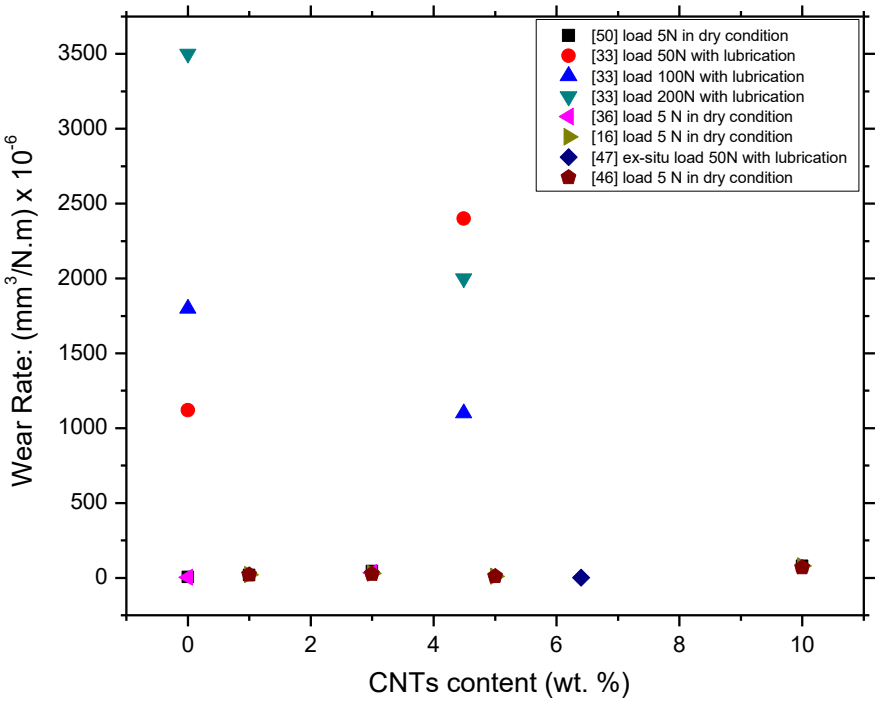
Si_3N_4 is a promising structural ceramic material with high strength and high toughness that could replace metals in high temperature applications.

INFLUENCING FACTORS:

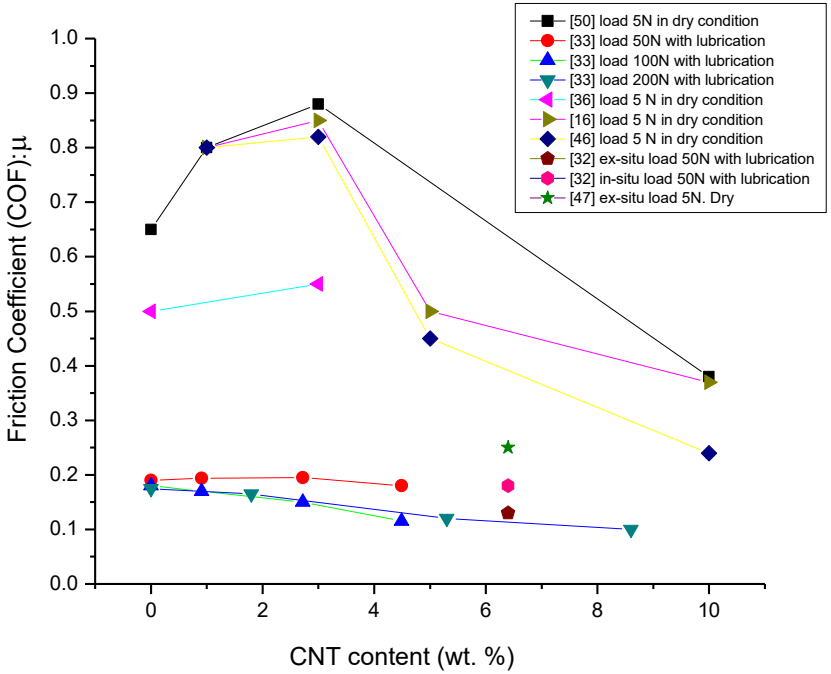
- Properties of nanofillers: Carbon nanofillers possess exceptional intrinsic mechanical, electrical and thermal properties.
- Interface between Si3N4 and carbon nanofillers: Improves the interfacial load transfer through functionalization.
- Dispersion of nanfillers in silicon nitride matrix: Carbon Nanostructures tend to agglomerate degrading the properties of nanocomposites.

Influence of CNTs on Wear rate and coefficient of friction

Wear Rate

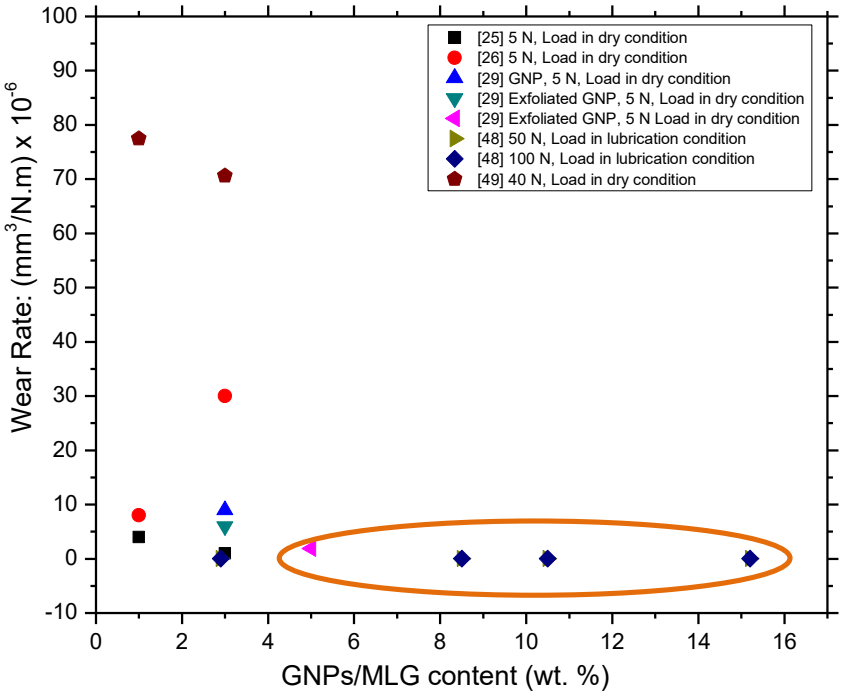


Coefficient of Fricition

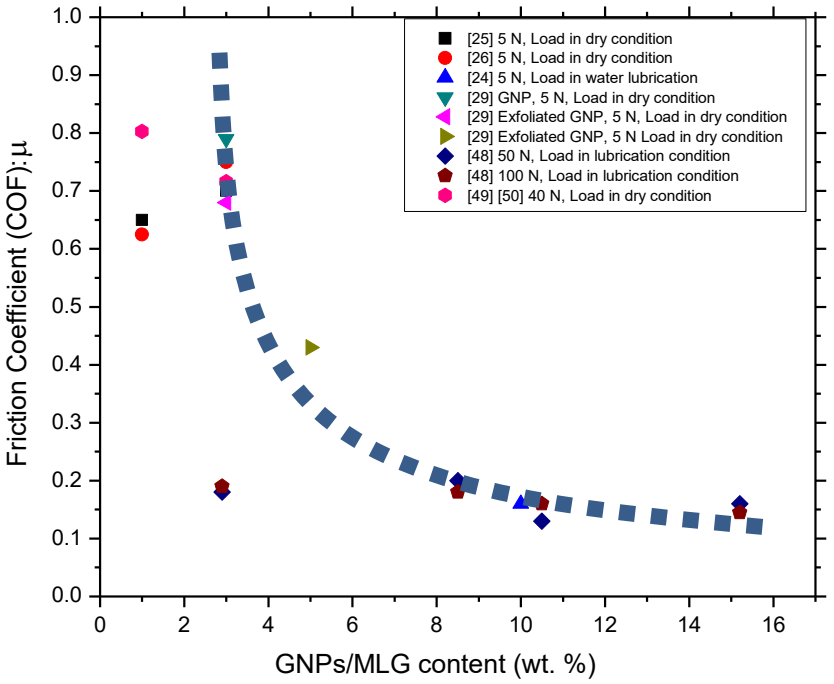


Influence of Graphene on Wear Rate and coefficient of friction

Wear rate



Coefficient of Friction



Influencing factors

The benefits of addition of nanofillers can be realized in tribological properties.

The uniform dispersion of nanofillers act as the lubrication and decrease the coefficient of friction and reduce the wear rate.

The main wear mechanism in the nanocomposite is abrasion accompanied with a pull-out of the carbon nanofibers which act in the interface as a lubricating agent.

Influential factors enhancing the tribological properties

- uniform distribution of CNTs in the matrix
- Load transfer efficiency,
- Structure stability of CNTs during processing in the matrix,
- Interfacial bonding between CNTs and matrix

Major challenges in integrating nanofillers in Si_3N_4

- Uniform dispersion
- Damaging of CNTs
- Oxidation of CNTs
- Clustering of CNTs
- Densification inhibition
- CNTs induce porosities in the composite
- Poor interfacial boding between matrix grains and CNTs

List of Publications 2017-2020

A. Qadir, Z. Fogarassy, Z. E. Horváth, K. Balazsi, and C. Balazsi, "Effect of the oxidization of Si3N4 powder on the microstructural and mechanical properties of hot isostatic pressed silicon nitride," Ceramics International, vol. 44, no. 12, pp. 14601–14609, Aug. 2018. (Impact Factor 2.986).
https://doi.org/10.1016/j.ceramint.2018.05.081

Awais Qadir; Katalin Balazsi; Csaba Balazsi; Jan Dusza "Processing and properties of S3N4 + MWCNTs composites from oxidized silicon nitride powder", Processing & Application of Ceramics, Sep 2019 (In Press) (Impact Factor: 1.144).

Awais Qadir, Pinke Peter, Jan Dusza, Tribological behavior of silicon nitride + carbon-based filler composites – A Review, Proceedings of Engineering Symposium at Bánki (ESB 2019), "Bánki Közlemények" (ISSN 2560-2810), Dec. 2019 (In Review)

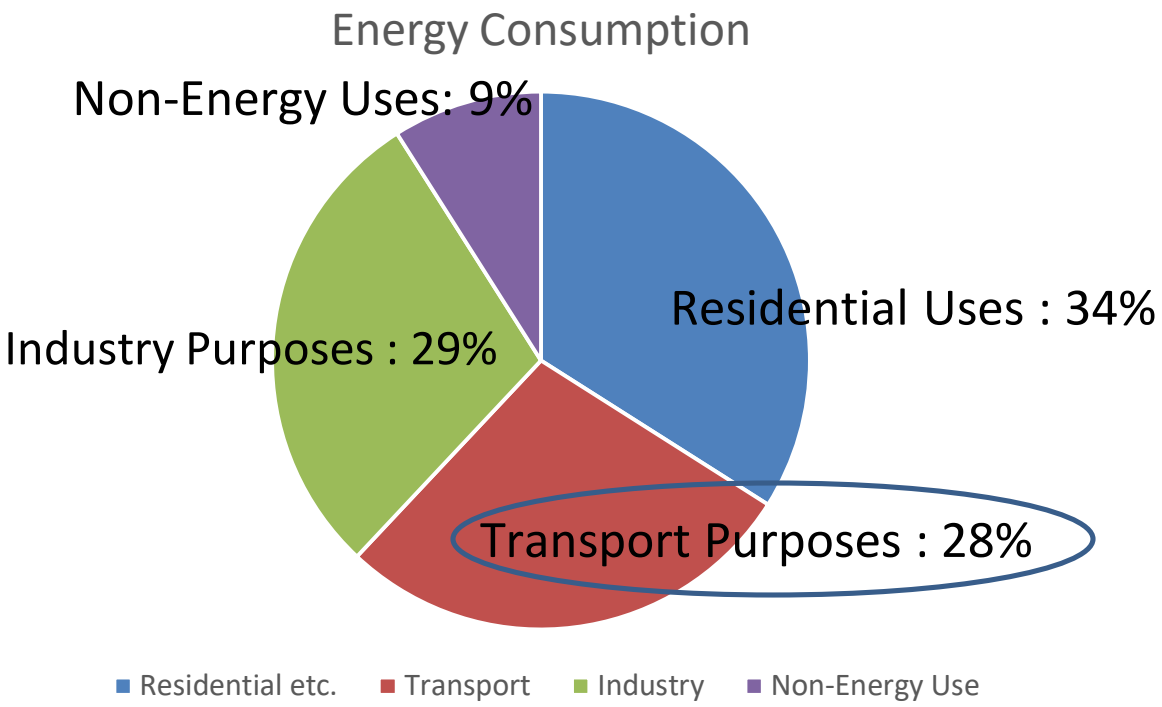
Awais Qadir; Pinke Peter; Jan Dusza; " CNTs reinforced silicon nitride composites - A review, Feb. 2020 (to be submitted) (Journal with IF).

Future Plans

- Mechanical Testing on Si_3N_4 + Graphene Composites
- Article writing on Si_3N_4 + Graphene Composites
- Thesis Writing

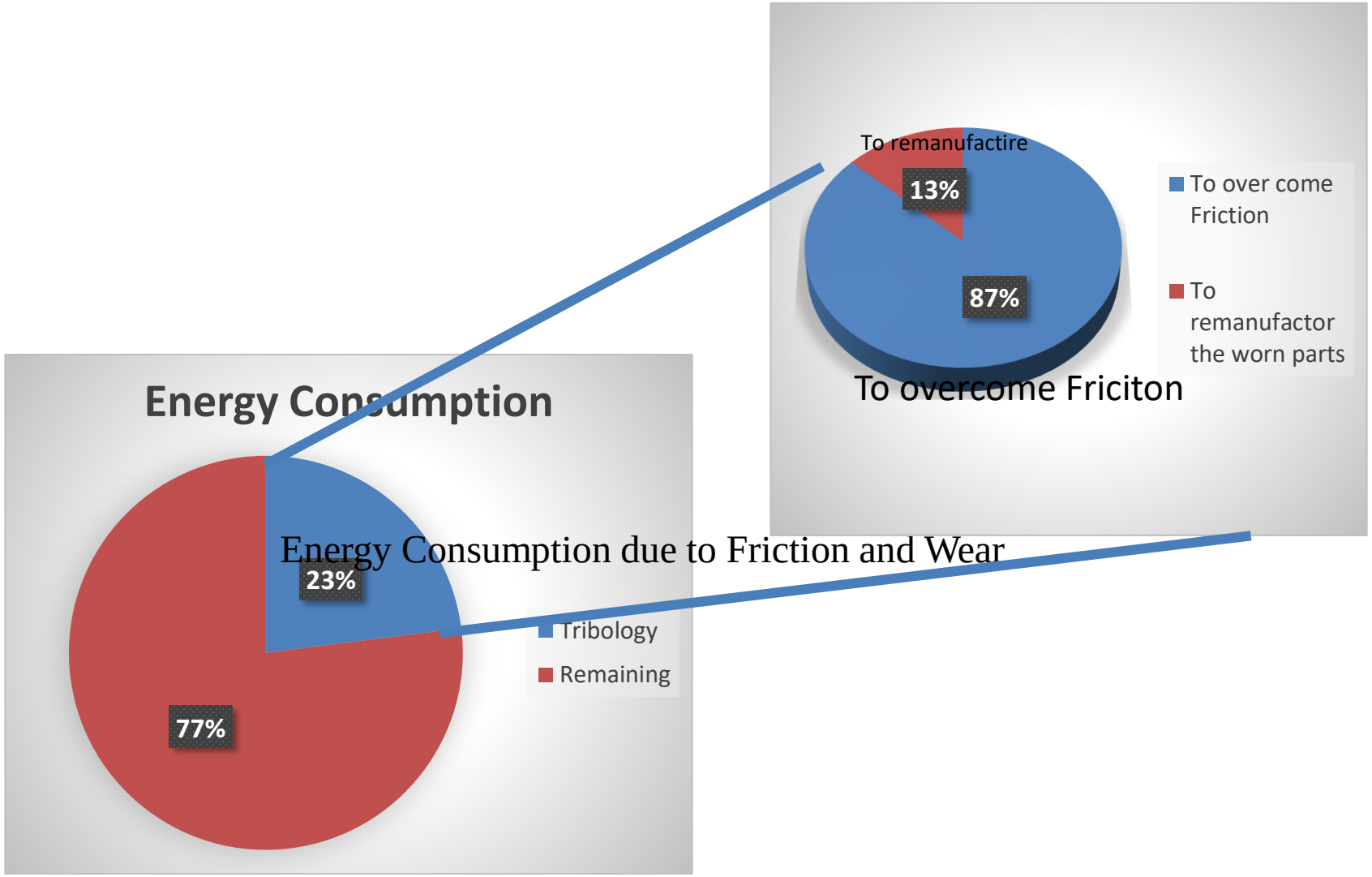
Global energy consumption

According to International Energy Agency Report 2016



In total, ~23% (119 EJ) of the world's total energy consumption originates from tribological contacts. Of that 20% (103 EJ) is used to overcome friction and 3% (16 EJ) is used to remanufacture worn parts and spare equipment due to wear and wear-related failures.

Energy Consumption due to tribology



Impact on Global Economy

- 7 L/100 km = 15.4 Euros (Normal Car)
- Cost of fuel per Km ≈ 0.084 €

Up to 40 bearings are in a car.

Ceramic bearings are 35% lighter and smoother surface than metallic ones.

After the reduction of weight:

Saving of money = 0.004 Euros per km

Over 1 billion cars in the world:

0.075 x 1 Billion = 4 million Euros per Km

Thank You for your attention!

Köszönöm a figyelmet!