AMT TCP Strategic Work Plan, 2020-2030

Energy supply and demand: COP21 pledged significant carbon reduction in the next ten years to curb global temperature rise to less than 2 degrees. The transport sector worldwide accounts for 24% of direct CO_2 combustion emissions in 2016. The world vehicle fleet stands at 1.3B and is projected to grow to 2B by 2035. While the demand for energy largely remains the same, but the energy supply is shifting. US have become a major source of supply of oil and gas, which led to oil price instability. Wind and solar continue to be installed to prepare for the electrification of the transport sector by 2050. The world's industries appear to agree with the electrification and began investing heavily in EV in the last several years.

Meanwhile, the 4th industrial revolution is taking shape. Autonomous vehicles, internet of things (IoT), artificial intelligence (AI), machine learning (ML), are enabling and creating smart cities, digital manufacturing, 3-D automated printing, advanced robotics, and automated autonomous systems. Transportation will be going through revolutionary changes from ownership driving to transportation on demand, autonomous EV, and zero carbon systems. For all of these advances to be realized, materials technology remains the building block for the next generation of self-healing, self-adjusting autonomous systems.

Many of the changes will take place in the ten years. At the same time, the legacy vehicles in the world will continue to produce carbon emission. Reducing this carbon source, dramatic energy efficiency improvement, design, ride share, and fast low cost public transportation will be needed.

AMT strategy, therefore, is to continue the current fuel efficiency effort while follow carefully the changing material fabrication, and the evolving digital manufacturing of the future. From a material technology perspective, both the bulk properties and the surface properties may change from our current manufacturing processes. Opportunities may emerge that some of the new manufacturing techniques may allow us to modify material properties on demand. Such properties would accelerate our goal and create innovative material designs. The surface region can be modified to embed sensors and actuator to enable self-adjust properties as external conditions change. For autonomous systems, self-maintenance and self-repairing may be necessary to reach their full potential. AI and ML will be important tools to aid the development of these processes. Appropriate new Annexes may be established to create new material technology of the future.

AMT TCP Planned Contribution: AMT has world class materials network across four continents focus on developing fuel efficient material technologies. The network provides a forum for material experts to exchange latest information and work together as a team to improve fuel economy in their regions as well as addressing global challenges in material technologies. Engine test results (or results from unique facilities) can be shared to enhance the combined capabilities, personnel exchanges (e.g. Germany and Canada; China and US) can jump start collaboration on shared interests. International round robin studies (e.g. in thermoelectric material measurements) enable mutual learning experience together, sharing expertise and resulting in international standard practice. The diffusion of knowledge and expertise also enhances local economic well-being. In working together, we not only enhance the probability of success, we also multiply our resources towards our common goals. The goal of improved energy efficiency is in line with CERT's and EUWP's goals of reducing carbon emission.

Scope: AMT focuses on creating innovations in material technologies to increase energy efficiency and reduce carbon emissions to allow global warming mitigation.

Vision: By 2030, AMT TCP will provide innovative materials technologies to enable the creation of next generation of energy efficient transportation systems.

Mission: To develop, create, assist, and explore innovative materials technology to accelerate the energy transition to electrification of transportation. This includes the development of test methods, testing, verification, demonstration, and potential commercialization.

AMT TCP program for next 5 years: The Strategic direction for AMT-TCP continues to focus on fuel economy improvement of vehicles by accelerating adoption of advanced materials for lightweighting, friction reduction, and thermal management. We have achieved significant progress in friction reduction, resulting in 2% fuel economy improvement.

AMT program for the next 5 years:

1) **Friction reduction (Annex IV):**

- Recent progress 2015-2020l and project to 2025: Surface technology including surface texture, coatings, and ultra-low viscosity lubricants. The low viscosity lubricant, jointly developed with an industrial partner has achieved 2% fuel economy gain (using standardized engine tests) over current commercial lubricants. The engine with surface textured parts achieved another 3% improvement in an engine chassis dynamometer tests. This would save 1.4 Mton carbon emissions per year in the US alone.
- Rationale for future work: the project has closed. Future work will be included in Annex XII, tailored surface engineering.

2) **Thermoelectric materials (Annex VIII):**

- Recent progress 2015-2020 to 2025: Five international round robin tests on thermal electric materials (Bismuth Telluride, half-Haussler) and devices have been conducted. The measurement methods have been improved.
- Rationale for future work: current studies on devices are continuing and the Annex will expand to include thermal management and EVs in the future.

3) **Model-based coatings (Annex IX)**

- Recent progress 2015-2020 to 2025: Multiscale computational material models have been developed. The effect of surface roughness on coatings has shown significant influence. The models have now incorporated lubricant effect on substrate damage.
- Rationale for future work: will continue to investigate how coatings can protect surface damage under a wide variety of operating conditions. Will also explore optimum coating design for specific applications.

4**) Multi-materials Joining (Annex X)**

- Recent progress 2015-2020 to 2025: A data base listing various joining techniques using standard sample specimens has been developed; various joining method of dissimilar materials are under investigations. .
- Rationale for future work: the project will continue to generate data on the mechanical properties of various joints. The data base will be made available to industry.

5) **Automotive Glazing (Annex XI):**

- Recent progress 2017-2020 to 2025: Advanced polymer replacing glass panel on cars is being tested in a vehicle, showing fuel economy improvements due to increased insulation and weight reduction. Currently advanced coatings are being tested
- Rationale for future work: continue to test various coatings to enhance reflectivity and optical properties.

6) **Tailored Engineered Surfaces for energy efficiency** (proposed Annex XII)

- New Annex proposed: based on the progress made from Annex IV, the Annex will explore multiscale multifunctional surface treatment for self-adjusting surfaces to maximize energy efficiency.

Anticipated output and impact:

1) The low viscosity lubricant has been commercialized by the industrial partner. The surface material technology is being tested in engines by an engine manufacturer. Results showed 3% energy efficiency improvement.
2) More efficient and cost-effective thermoelectric materials will emerge as a result of the standards set by the Annex VIII, making waste heat recovery viable for trucks and other applications, improving fuel efficiency.
3) The model-based coating research will provide design guidelines for future coating solutions to be used in engine companies with enhanced durability and performance.
4) A joining method selection guide with mechanical properties of the joint will accelerate the development of multimaterials vehicles, creating optimum weight reduction and longer durability. Limited multimaterials vehicles have already been commercialized by vehicle manufacturers.

Membership: priorities for expansion

Current members:Germany -- Bundesanstalt für Materialforschung und –prüfung (BAM); United States -The United States Department of Energy (DOE); Canada – CanmetMATEIALS, Natural Resources Canada; China – Lanzhou Institute of Chemical Physics, Chinese Academy of Sciences, Shanghai Institute of Ceramics, Chinese Academy of Sciences; United Kingdom- NPL, UK; Australia- Curtin University, Perth, Australia; Finland – TEKES, Finland (VTT designated by TEKES); Israel – Technion, Haifa, Israel; Korea – Korea Institute of Energy Technology Evaluation and Planning (KETEP)

Austria – Österreichische Tribologische Gesellschaft – ÖTG, pending IEA official approval

Brazil -- Universidade Federal do Rio Grande – FURG, pending IEA official approval, ExCo voted grant 2 years temporary membership to enable participation now.