IFToMM for Sustainable Development Goals

Bilbao, 22 - 23 June 2023

BOOK OF EXTENDED ABSTRACTS

Universidad del País Vasco Euskal Herriko Unibertsitatea
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IFToMM ITALY

INDEX

SDGs Initiatives in Ricoh Technology R&D

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Keywords: SDG7, Inkjet, Functional Material, Printing, Painting, Carbon Neutrality, Circular Economy

1 Background

The Ricoh Group considers it essential to simultaneously protect the environment while generating profits. We accordingly practice environmental management, through which we strive to reduce our eco-footprint and improve the Earth's regenerative capabilities Groupwide. We seek to materialize social sustainability by tackling material issues of contributing to carbon neutrality and a circular economy. We have set Ricoh Group Environmental Declaration and environmental goals for 2030 and 2050.

Ricoh Group Environmental Declaration
We proactively reduce environmental impact and strive to improve the Earth's self-recovery capabilities to achieve a zero-carbon society and a circular economy through business.

In this lecture, I will introduce current Ricoh's initiatives and measures in the technology R&D division regarding the two main factors, a carbon neutrality and a circular economy.

2 Contents Outline

2.1 Carbon Neutrality

We have conserved energy and tapped renewables at domestic and overseas sites to help restrict the global temperature rise to 1.5°C. We maintain renewable power contracts with retail electricity providers and procure renewable power certificates. We plan to switch to entirely renewable energy at our overseas sites by 2030. We use 100% renewable electricity to manufacture our A3 MFPs worldwide.

As a current effort, there are a reuse rate of 80% that guarantees the product according to predetermined quality standards in Japan. In our global site, there are re-

use machines with a reuse rate of about 90% or more that are sorted and regenerated according to local standards. Compared to new machines, the reconditioned machine released in June 2021 has reduced CO2 emissions by 62% in the manufacturing process and 19% in the entire life cycle.

Furthermore, we are developing technology for inkjet coating of functional materials in our research institute, and we have focused on providing products and solutions to help customers decarbonize while creating businesses in response to climate change.

2.2 Circular Economy

The transition to a circular economy has become a common recognition as a global issue next to climate change countermeasures. With countries everywhere deploying policies for such a transition, we believe that that developing products and services worldwide that incorporate these policies and market trends will create opportunities for us by enabling us to differentiate ourselves competitively and create new markets.

We have sold remanufactured products since 1997, tailoring our operations to regional market needs. We guarantee high-quality remanufactured products to be as good as new. We market them as the GreenLine series in Europe, the Americas, and elsewhere in Asia. In February 2022, nine models of the GreenLine series models in the Americas became the world's first remanufactured MFPs to achieve ENERGY STAR certification under specification version 3.1.

We believe that we can continue to create new value by adding advanced digital technology to years of expertise in optical, imaging, materials, manufacturing, and controls and systems technologies, combining these capabilities with unique ideas.

We will introduce new system technology that help materialize a circular economy.

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Heat and mass transfer characteristics in drying process of viscous liquid film

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Keywords: SDG12 · Evaporation rate · Liquid film · Viscosity · Diffusion constant · Power consumption

1 Introduction

Digital printing includes direct mail, package printing, magazine/book printing, and catalog printing. As printing methods, there are laser printers that use toner and inkjet printers that use ink. Inkjet printers use water-based ink, oil-based ink, and UV curable ink, and which ink type of use is selected according to the application. In the case of water-based ink, approximately 90% of the constituents are water, which must be removed by drying after printing, and there are several drying methods. These include atmospheric drying using a heater, forced convection drying using hot air, and IR heating. The use of heaters and hot air systems tend to consume large amount of electric power. Therefore, it is desirable to reduce the power consumption from the viewpoint of global environment protection.

In this report, by analyzing the evaporation behavior of water-based ink, we propose a new way of thinking about the ink properties that affect the evaporation speed to reduce drying energy and ensure a sustainable society.

2 Method

2.1 Experiment procedure

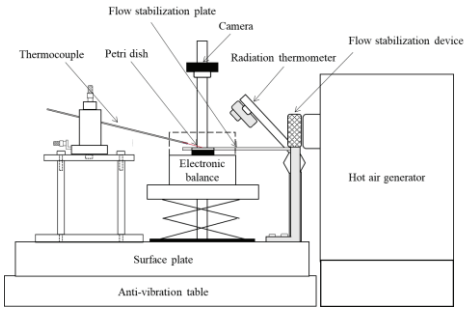

Fig.1 Experimental setup for drying of liquid film

In the experiment, model ink was prepared using distilled water, polyethylene glycol (PEG), and silica as a pigment. Liquid film was formed using model ink and heated by forced convection at 70°C. Weight and temperature of the liquid film was measured in the drying process and evaporation rate was calculated.

3 Results

3.1 Effect of ink composition on mass transfer

Figure 2 shows the molecular weight dependence of the evaporation rate of PEG. As the molecular weight increases, the evaporation rate decreases. Since the viscosity coefficient of model ink depends on the molecular weight, it is assumed that the mutual diffusion coefficient of water molecules decreases as the molecular weight of the polymer increases [1,2]. As a result, the migration rate of water molecules to the gas-liquid interface is slowed down, and the evaporation rate is consideed to be reduced.

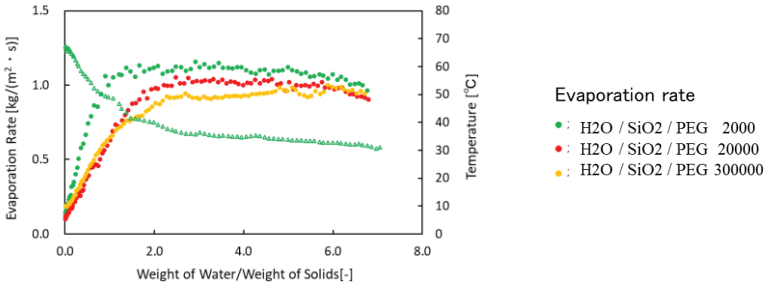

Fig.2 Effect of PEG molecular weight for Evaporation rate

4 Conclusions

The mass transfer was greatly affected by the constituents, and the molecular weight of PEG affected the evaporation rate. It was found that the decrease in the evaporation rate is related to the increase in the viscosity of the liquid. In the future, it is desirable to investigate a method to reduce the diffusion coefficient during ink evaporation

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Optimal Design of Gravity Compensator for Robotic Manipulators for Energy Saving Drive Widely within Workspace

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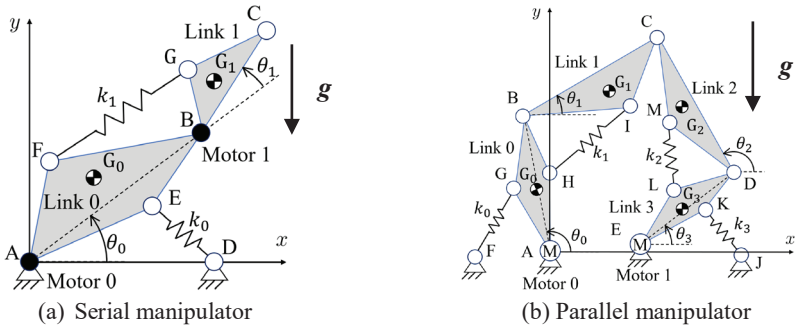
Keywords: SDG7, Robotic and Mechatronic, Robotic Manipulator, Dynamics, Gravity compensator, Spring balancer, Optimal Design, GA

1 Introduction

Improving energy efficiency of industrial robots in factories is one of the key issues to achieve SDG7 [1]. Because robotic manipulators with multi-DOF must generate large holding torques to support both of the manipulated object and their own moving links against gravitational force, energy consumption becomes large. To reduce this energy consumption, various gravity compensators using springs or dead weight are proposed [2], however, almost of them deal with a specified trajectory or configuration of robot. We thus propose an optimal design of gravity compensator with many linear springs connected between links. This compensator is effective widely within the specified workspace of the robot.

2 Gravity Compensator with Linear Springs

Planar serial and parallel manipulators with 2DOF shown Fig. 1 are optimized. Many lineal springs are attached between links via revolute pairs on links as shown in Fig.1. The stiffness and natural length of spring are assumed constant and attaching positions on links are set as design variables.



(a) Serial manipulator (b) Parallel manipulator

Fig.1 Planar manipulators to be optimized

3 Optimization

For an example, sector workspaces and several linear trajectories shown in Fig.2 are assumed. Total energy consumption during positioning motion along trajectories are calculated as an objective function. Link dimensions and properties of the parallel mechanism are predetermined so as to obtain the same workspace and elastic deformation due to external load as those of serial manipulator. Genetic algorithm is adapted for this optimization.

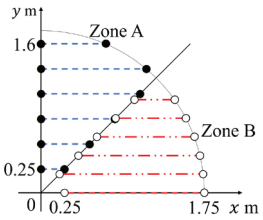


Fig. 2 Specified workspaces

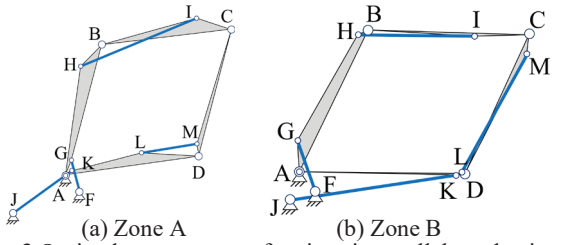


Fig. 3 Optimal arrangement of springs in parallel mechanism

Table 1. Energy reduction rates and comparison between serial/parallel mechanisms

Movement zone	Serial	Parallel	(Serial – Parallel) / Serial
Zone A	74.88%	87.64%	0.5006
Zone B	81.45 %	82.36%	0.7203
Zone A+B	70.27%	79.96%	0.5888

4 Results and Discussion

Fig. 3 shows examples of optimized arrangement of springs for parallel mechanism. Table 1 shows that the energy reduction rates for Zone A, B and Zone A+B, which are calculated as the reduced energy per energy consumption without gravity compensator, and the comparison of energy consumption between serial/parallel mechanisms. The results reveal that the optimized gravity compensator can reduce energy consumption for both mechanisms and that optimal energy reduction ratio changes as the specified workspace. Therefore, it may be effective to easily change spring arrangement for each specified workspace. Also, parallel mechanism is superior to serial mechanism under the same condition.

5 Summary

Optimal gravity compensator with only linear springs for robotic manipulators is obtained and is confirmed effective and useful. Optimal spring arrangement adapted to workspace will be investigated in the future.

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Visualization and Numerical Analysis of Temporal Change of Ink Viscosity over the Depth-wise Direction at Inkjet Head Nozzle

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Keywords: SDG6, Inkjet printing, Evaporation, Diffusion, Optical coherence tomography, Dynamic light scattering.

1 Background and Objective

Digital printing, such as inkjet printing, can be printed with little or no waste liquid in principle. This means that most of the ink filled in the inkjet head (IJ head) can be used to form images on paper or other media. However, in order to print with consistently high quality, some ink may be discarded from the head, resulting in waste. Since ink near the nozzle has a gas-liquid interface, volatile components of the ink evaporate from this interface when no ink droplets are ejected. Depending on the image pattern to be printed, there may be nozzles that do not eject for a long period of time, and the evaporation of volatile components may cause the ink to partially increase in viscosity. If the viscosity increases to an extreme, it becomes difficult to eject the ink at the targeted amount and speed, and therefore, the process is used to discard the ink before ejection failure occurs. Because the ink is considered to increase in viscosity from gas-liquid interface, if the change in viscosity distribution over the depth-wise direction can be observed, the amount and time interval of ink to be discarded can be determined, and the amount of waste can be minimized.

2 Experiment and Result

Observation of the viscosity increase process over the depth-wise direction was conducted using a glass capillary instead of the nozzle section of the IJ head and a model ink mixed with water, glycerol, and silica particles instead of a water-based pigment ink. The time variation of the diffusion coefficient distribution of silica particles was obtained by a combination of optical coherence tomography (OCT) and dynamic light scattering (DLS), and visualized as a substitute index for the solvent viscosity. When a tomographic image of a colloidal solution is acquired by OCT, the depth-wise distribution of speckles generated by particles can be obtained. If the particles are in motion, the speckles in the tomographic images will fluctuate over time according to their motion state. Therefore, by analyzing the temporal changes in the tomogram

based on DLS method, the distribution of the particle motion state can be measured. In this study, changes in the diffusion coefficient of particles were determined assuming that the particle size does not change with evaporation and so on.

Figure. 1 shows the diffusion coefficient changes at depths of approximately 0.1 and 0.3 mm. Although there are some variations in the graph, it shows that the diffusion coefficient decreases with time, i.e., the viscosity increases at each depth. There was no significant difference in behavior with depth. This indicates that while glycerol is concentrated by water evaporation from the surface, there is a remarkable diffusion phenomenon that homogenizes this concentration. To confirm the validity of this visualization result, numerical calculations were conducted. The viscosity change was obtained by solving the diffusion equation with flow due to evaporation. The results are shown in Fig.1. The results show that the particle diffusion coefficient changes in the same manner as the measured results, and the viscosity increases with a relatively uniform distribution, at least at the depth position observed in the experiment.

3 Conclusion

By combining OCT and DLS, the depth-wise viscosity increasing process was observed in an environment simulating an IJ head nozzle. The results visualized in this study was confirmed to have a behavior close to that of the numerical results.

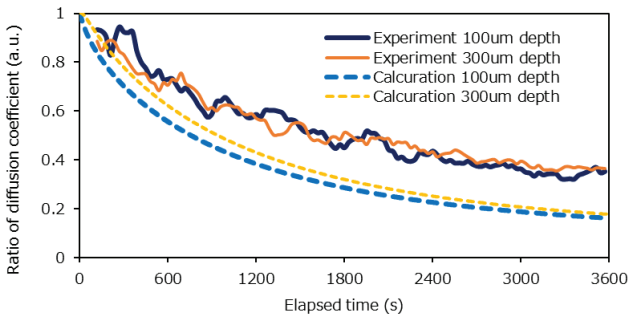

Fig. 1. Temporal change of the diffusion coefficient of particles at each depth. Solid lines represent measured values and dashed lines represent numerical results.

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Mechanical study of the submersible mixer structure of a wastewater biological treatment plant.

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Keywords: SDG6, mechanical design, vibration analysis, fatigue failure, wastewater decantation.

1 Introduction

In 1979, the Bilbao Bizkaia Water Consortium "CABB" initiated the Integral Sanitation Plan for Metropolitan Bilbao, which has enabled the recovery of the good ecological state of rivers, estuary and beaches for the enjoyment of the citizens. Domestic and industrial wastewater is collected and transported to the Galindo wastewater treatment plant (WWTP) in Sestao city. Designed to treat an average daily volume of 350,000 m^3 of wastewater, equivalent to more than one million inhabitants of Bizkaia, this plant is the cornerstone of the entire system. In 2001, the biological treatment came into operation, and the estuary has regained a suitable ecological status for numerous species of fish and birds. In 2019 Water Hall "CABB" was established in the Faculty of Engineering Bilbao to solve real problems, such as study case.

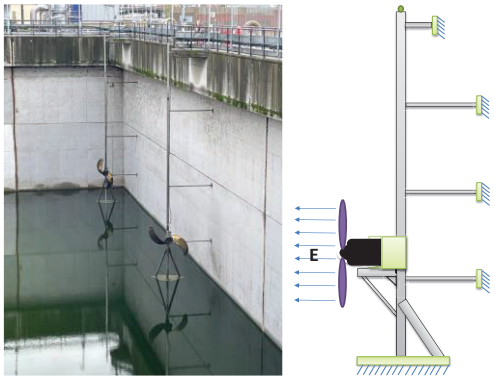
2 Case study

During the primary decantation process, which is mainly aimed at removing suspended solids, the water from the sand traps is distributed to 11 rectangular decanters measuring 58 m x 20 m by means of a channel equipped with 16 mixers to prevent sedimentation. These mixers are of the submersible type and they are positioned using a support structure with a slider attached to a cable that allows them to be raised or lowered to the desired position along a steel mast (see Fig. 1).

Sometimes the masts break their fastenings to the wall. On other occasions, it is even the mast itself that ends up breaking and makes it impossible to extract the mixer while the basin is full. These two situations are undesirable because they require the shutdown of the corresponding basin, thus limiting the station's treatment capacity.

The aim is therefore to analyse the reasons that are causing the mechanical failure of the structure and to develop a model that allows the design of a structure and the corresponding anchoring system to avoid stoppages to carry out repairs. To this end, a visit was made to the Galindo WWTP facilities to verify the various failings in the

structure. In addition, it was found that the structure is subjected to vibration-type excitation, which is probably causing fatigue failure of some elements. Additionally, we remember that the SDG6, associated to the present work, seeks to ensure safe drinking water and sanitation for all, focusing on the sustainable management of water resources, wastewater and ecosystems.



(1a) (1b)

Fig. 1. Mixers at the bottom of the wastewater basin: real photo (1a), simplified model (1b).

3 Challenge resolution

A study is carried out to analyse the nature of the loads on the structure to, together with the current geometry of the structure, develop a finite element model. This model will provide information on which are the critical areas and this will serve to improve the current design. At the same time, it will be used as a basis for defining a new support structure to suit the new plant requirements.

The main failure modes such as mast strength, vibration behaviour (natural frequencies and forced response) and the fatigue behaviour of the different elements will be considered. Special attention will be paid to welded joints as a joint method particularly sensitive to fatigue failure. In addition, solutions are proposed to dampen the effect of vibrations on the bolted plates joints to the basin walls.

4 Conclusions

In the primary decantation process, mixers to prevent sedimentation are a key system for water cleanliness and sanitization. The design of a support structure for the agitators is a key aspect that allows the proper operation of the WWPP. Of course, this has an immediate impact on economic repair costs that are minimised as well.

In this work, the structural behaviour of the system has been analysed by investigating, first, the origin of the loads and their nature. These loads together with the existing structure have allowed the development of a model to evaluate the failure and to design a new structure that allows the system to work without interruptions.

Alternative methods of facial reconstruction with applicability in archaeology

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Keywords: *SDG17*, *dialogue between technologists and humanists*, *facial reconstruction – alternative methods (with application in archaeology)*

Extended Abstract

1. Introduction. The research context

In contemporary society, marked by unprecedented technological development in the history of humanity and globalization, the dialogue between technical sciences and the humanities is necessary, especially when technical discoveries and applications advance the level of public understanding or when these discoveries are used outside of norms and clear and assumed conventions, social disturbances occur with serious consequences. On the other hand, engineering serves the progress of society, and contributes to finding the best solutions to meet the Sustainable Development Goals of the UNESCO 2030 Agenda [1].

We frame our work in SDG17, illustrating a model of dialogue between the applications of mechanical engineering and archaeology, having as the focus of the study facial reconstruction with applications in the methodology of research in archeology.

2. Methods of face reconstruction

Facial reconstruction is needed and used in various fields of activity, from medicine, art, to forensics and archaeology. In our presentation, we highlight the evolution of

different facial reconstruction methods used: two-dimensional reconstruction [2], the classic three-dimensional manual technique (e.g. Manchester combined method) [3], computerized facial reconstruction [4]. For the classical manual technique, various methods are used, but the Manchester combined method has been found to be the best and most accurate method for positive identification of an individual. On the other hand, manual methods are labor intensive. Computer forensic facial reconstruction can also mimic the manual method of facial reconstruction.

3. The case study presents a stage of our research activity through which we want to use different technical applications for the facial reconstruction of a skull from the 10th century - artifact discovered in the archaeological excavations in Timiș County (Romania) by researchers from Faculty of History of West University of Timisoara [5]. With the instruments made available by our Faculty (scanner, 3D printer), at this stage we only realized part of the facial remodeling: recreating the temporal muscle, using a mixed method, the Russian anatomical method (part of the three-dimensional manual technique) and computerized method via CAD software and a point by point generation of lines and finally the surface of the muscle.

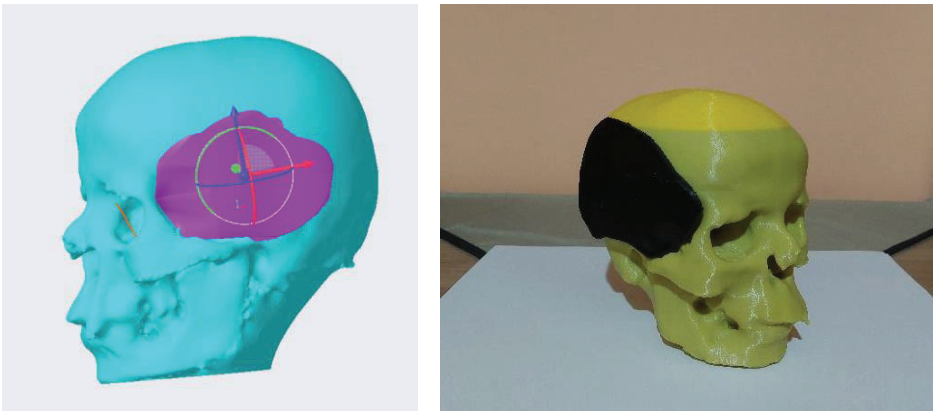

Fig. 1. Placement of the temporal muscle on the skull (model versus reality)

4. Conclusions

Computerized remodeling of the missing individual is significantly easier compared to the manual method and also helps in simplifying the training of the practitioner. Our initiative represents a first in the Timisoara university center, which we want to develop through interdisciplinary methodological collaborations, between our field and archaeology.

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Within the aims of IFToMM Cross Disciplinary Group1
Securing our Future Environment - Air, Water, Energy
I4SDG 2023
IFToMM for Sustainable Development Goals
BILBAO, Spain — June 22-23, 2023
IFToMM

The key role of advanced research on engines and powertrains for sustainable mobility, transportation and power generation

Keywords: SDG7, SDG9, SDG13

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EXTENDED ABSTRACT

The aim of this presentation is to give an overview of the objects of study and the scientific disciplines involved in research of engines and powertrains, as well as to show the cross-coupling of this area with the other areas of IFToMM. Examples of advanced research within both traditional and emerging technological concepts are presented. These result in technical solutions that ensure sustainable development in the areas of mobility, transportation and power generation.

Taking a look at the current state in the mentioned areas, we can see increasingly stringent, legally imposed vehicle emission standards that are becoming a strongest factor affecting engine manufacturers. As a result, there is a massive push towards vehicle electrification, particularly in the automotive industry – a trend that will continue and promises to become even stronger in the years to come. The emphasis is put here on electric drives, with intensive research conducted on power battery as energy storage and fuel cell as an alternative energy transformer. However, there are also other technologies targeting the reduction of environmental footprint, both on a local (air quality) and on a global scale (climate). Thus, more effort and time is spent to develop cleaner internal combustion engines, based not only on an improved design and control strategy of the combustion process, but also on new and alternative fuels, including hydrogen, ammoniac and e-fuels, leading to stricter requirements on finer geometric design, advanced material properties and more exact manufacturing. Besides that, hybrid powertrains continue to take a considerable share of the cars produced worldwide, too.

To get a clear view over the current state and the trends of the science and engineering in the large and fast-growing field of engines and powertrains, it helps to start the consideration with definitions and classification.

From the structure point of view, a powertrain consists of engine and transmission that transfers the generated mechanical movement and forces to the target machine part, tool, object or medium. Further, the engine and powertrain contain functional subsystems or units such as crank train, valve train, lubrication system, cooling system, turbocharger, gearbox and transmission. On the other hand, the engine and powertrain are usually a part of larger system such as vehicle or power plant.

Depending on the functional purpose of these larger systems there are two types of powertrains (being a part of different machines):

a) Vehicle powertrains: these include all automotive powertrains (built in into cars, trucks, commercial vehicles, construction machinery, racing vehicles), as well as ship, aviation and rail drives;
b) Stationary powertrains: these are power plants of diverse types for generating electricity or heat (emergency generators, wind turbines), various technological systems (e. g. industrial pump systems), as well as machine tools.

Based on the type of energy that is converted into a kinetic energy of mechanical movement, different engine groups can be defined, with the most common ones being the heat or thermal engine (represented by the sub-groups of internal combustion engine and the gas turbine, which are then further differentiated by the fuel type used), and electric motor (with its multiple sub-groups).

To analyze and design the systems and subsystems mentioned above, application of the following disciplines – branches of multi-physics, mechanics and mechatronics – is essential: multi-body dynamics, vibration analysis, durability, tribology, acoustics, computational fluid dynamics, combustion chemistry, control strategy.

Being a multi-object and multi-discipline scientific field, engines and powertrains have a good potential to become an area for cooperation within IFToMM, especially related to sustainable mobility, transportation and power generation area.

The main SDGs addressed in the presentation are:

SDG7 - Clean and affordable energy: cleaner and more efficient engines and powertrains are needed for the mobility and transportation; as a parts of powerplants based on renewable sources of energy (e. g. wind powerplants), powertrains are designed to supply clean, environment friendly and affordable energy.

SDG9 – Industry, innovation and infrastructure: automotive and similar transportation industries are one of the most innovative sectors of the economy; their operation also implies a general presence of respective infrastructure.

SDG13 – Climate action: decarbonization of vehicles and powerplants is the hottest research topic in the area of engines and powertrains.

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