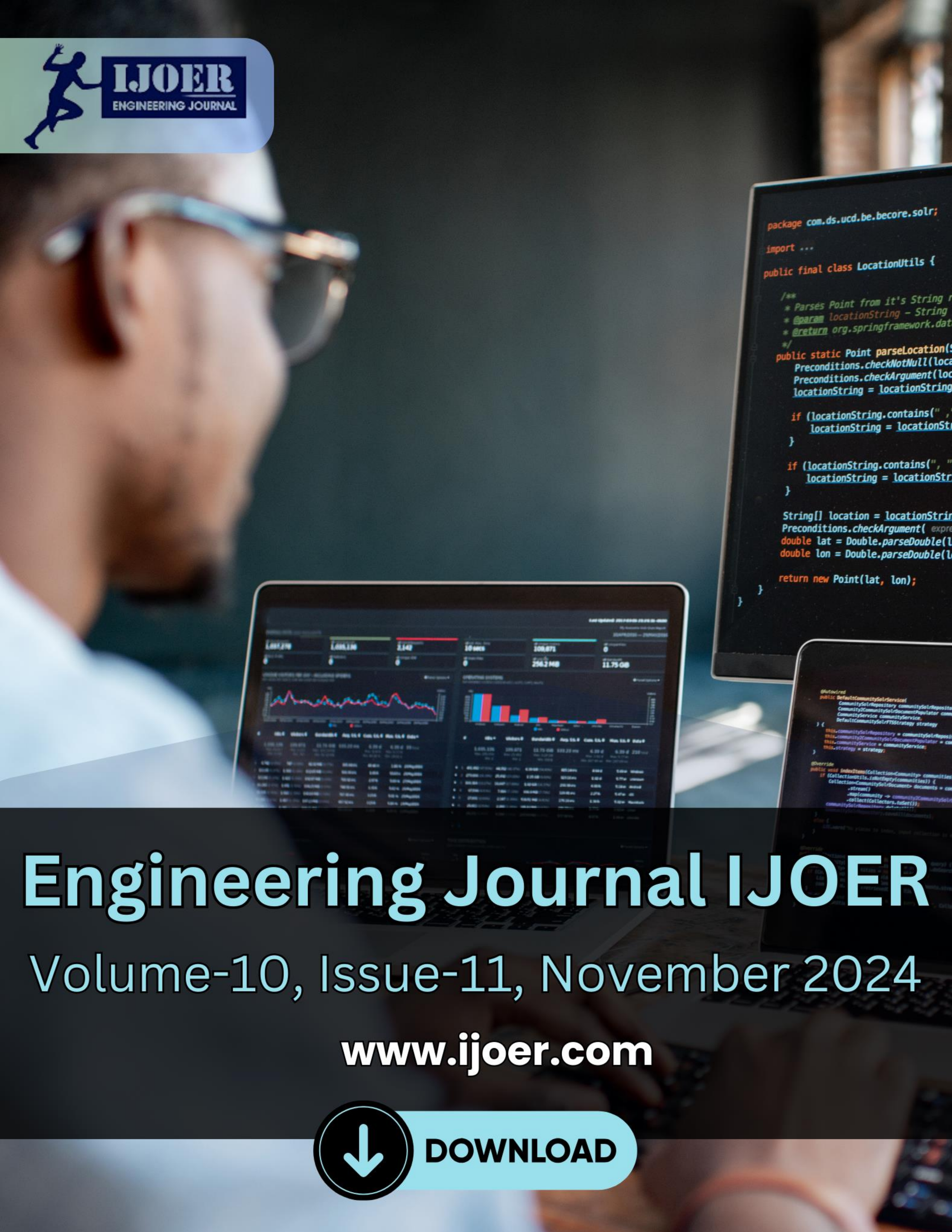

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Preface

We would like to present, with great pleasure, the inaugural volume-10, Issue-11, November 2024, of a scholarly journal, *International Journal of Engineering Research & Science*. This journal is part of the AD Publications series *in the field of Engineering, Mathematics, Physics, Chemistry and science Research Development*, and is devoted to the gamut of Engineering and Science issues, from theoretical aspects to application-dependent studies and the validation of emerging technologies.

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Each article in this issue provides an example of a concrete industrial application or a case study of the presented methodology to amplify the impact of the contribution. We are very thankful to everybody within that community who supported the idea of creating a new Research with IJOER. We are certain that this issue will be followed by many others, reporting new developments in the Engineering and Science field. This issue would not have been possible without the great support of the Reviewer, Editorial Board members and also with our Advisory Board Members, and we would like to express our sincere thanks to all of them. We would also like to express our gratitude to the editorial staff of AD Publications, who supported us at every stage of the project. It is our hope that this fine collection of articles will be a valuable resource for *IJOER* readers and will stimulate further research into the vibrant area of Engineering and Science Research.

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Metal Hydride Hydrogen Storage Tank and its Certification for Use in Real Operations

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Abstract— *The article discusses the issue of metal hydride tanks for hydrogen storage, their types, distribution and direct implementation of tanks in the real operation of equipment. The article also deals with certification and describes all the necessary tests established by the standards, which the designed metal hydride tank must successfully pass. The article also mentions the design of a tubular metal hydride tank, the outer diameter of which is 60.3 mm.*

Keywords— Metal hydride, pressure tank, certification.

I. INTRODUCTION

The lack of traditional energy sources in the form of fossils in the world leads to the research and development of other renewable energy sources. Hydrogen is an energy medium that is considered a renewable energy source, but hydrogen is considered an energy carrier. To obtain energy from hydrogen, it is necessary to use a suitable device that can obtain, for example, electrical energy from hydrogen. Such a device is called a fuel cell, which can be implemented in static or mobile applications in cars and other transport devices. For hydrogen technologies to be used in everyday life, continuous research and development must take place in several areas. The biggest challenges for the implementation of hydrogen technologies in everyday life are the production, distribution and storage of hydrogen. Efficiently storing hydrogen represents a key task for the implementation of hydrogen technologies in the transport sector. The storage of hydrogen is difficult mainly because of the very low volumetric energy density under standard conditions, as well as other demanding properties. Especially in the transport sector, for example for cars, buses, trains, ships and others, it is important to have hydrogen storage options with high volumetric and gravimetric energy density to be competitive with other conventional systems. For this reason, various hydrogen storage concepts and technologies have been developed in recent years.

The most common way of storing hydrogen in the transport sector is through high-pressure storage in the form of compressed hydrogen in a gaseous state. Hydrogen in such systems is usually stored in steel tanks at pressures from 15 to 20 MPa, but when using steel tanks, it is possible to achieve only 1.5 wt.% and 10-12 $kg \cdot m^{-3}$ gravimetric and volume density [1].

To achieve more optimal operating parameters of high-pressure systems, higher pressures are needed in tanks of 35-70 MPa, the value of the hydrogen mass fraction is 5.5 wt.% and 40 kg·m-3 gravimetric and volume density. For this reason, classic steel containers cannot be used, as the gravimetric storage capacity decreases at higher pressures. For higher pressures, it is necessary to use composite tanks reinforced with carbon fibers. From a safety point of view, this method of hydrogen storage is not the most suitable for implementation in the transport sector due to extremely high pressures [1],[2]. Another way to store hydrogen is to liquefy hydrogen using cryogenic temperatures. High values of gravimetric and bulk density can be achieved with this method. The pressure in the tanks is much smaller 1 MPa, compared to high-pressure hydrogen storage, where the working pressure ranges from 35 to 70 MPa. Tanks for storing liquefied hydrogen are mostly double shelled with insulation between them. To store hydrogen in this way, extremely low temperatures of 20 K are required, and for this reason this storage of hydrogen in the transport sector is very energy intensive.

Chemical storage of hydrogen in the form of metal hydrides represents a promising alternative for use in mobile applications. Metal hydrides are formed by hydrogen atoms dispersed in the crystal lattice of the primary metal. This storage of hydrogen allows for large storage densities because the hydrogen atoms have a strong interaction with the primary material. A great advantage of this storage is the possibility of storage at low pressures in ranges between 1-2.5 MPa at ambient temperatures. Although metal hydrides are extremely safe, there are also disadvantages that make further research and innovation in this area necessary. One of the disadvantages is the gravimetric energy density, which is very low, leading to a high weight of the metal hydride tank. Also, during the process of hydrogen absorption into the interatomic space of the metal hydride, an exothermic reaction occurs and thus heat is released, which is a disadvantage. For example, with an alloy based on LaCeNi, up to 1 MJ of heat is released for 1 m^3 of stored hydrogen [3].

This disadvantage must be solved by cooling the metal hydride alloy during the process of refuelling hydrogen into the metal hydride tank, which can be solved in different ways. Due to the cooling of metal hydride tanks, several types were created, while the basic geometric configurations of the tanks can be categorized into the following groups: disk, chamber or tubular tanks [4].

The most promising tanks for mobile applications are tubular. In this type of tank, a metal hydride alloy is poured into a steel tank and two basic types are distinguished. The first type represents tubular tanks, the diameter of which is less than 30 mm to allow sufficient heat transfer in the radial direction.

The second type represents tanks whose diameter is greater than 30 mm. For such tanks, the necessary cooling system is implemented on the metal hydride tanks. The cooling system can be solved through passive cooling modules or active cooling modules.

In the next chapter, the design of a tubular metal hydride storage tank with the outer diameter of 60.3 mm, is dealt with, and then all the necessary tests that the designed storage tank must pass are mentioned for tank to be certified for use in mobile applications.

II. DESIGN OF TUBULAR METAL HYDRIDE TANK

When designing a tubular metal hydride storage tank, the outer diameter of the tank is 60.3 mm. This means that for the given storage tank it is necessary to integrate cooling not only around the perimeter of the container, but also directly inside for efficient removal of the generated heat to the inner wall of the metal hydride storage tank. The cooling of the tank in question is solved by means of cooling modules. Active cooling is located on the perimeter of the tank in the space between the primary body and the case. Passive cooling is implemented using an internal heat exchanger that is inserted inside the tank. The maximum working pressure of the designed tank is 30 bars. The material used in the design of the tubular tank is stainless steel type 316L. Maximum thickness of shell of designed tank is set to 2.6 mm. The design of the tank is shown in Fig. 1.

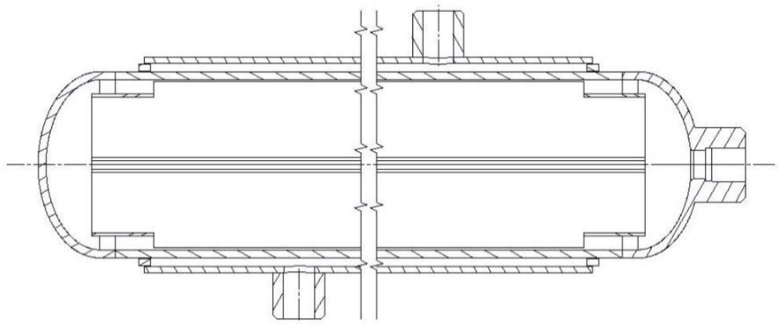

FIGURE 1: Designed tubular metal hydride tank

The given tank is verified by strength analyses using the FEM method. The maximum stress on the resulting tank at working pressure of 30 bars is 30 MPa, which is far less than the value of the yield stress of the selected material determined by the manufacturer.

Another part of this article is the listing and determination of all the necessary tests for the certification of the tubular metal hydride storage tank through the standard STN EN 13322-2 part 2.

III. TESTS FOR THE CERTIFICATION OF THE DESIGNED TUBULAR TANK

The STN EN 13322-2 standard, in addition to the structural design, also provides information on the actual construction and manufacturing of the newly designed storage tank and all the necessary tests that the designed storage tank must successfully pass.

When designing and manufacturing the designed tank according to the standard, the given tank must be made using seamless or longitudinally welded pipes with bottoms that are circumferentially welded. At the same time, it must be true that all welds on the structures can be checked with the naked eye. This means that the primary tank of the designed tank, which houses the passive internal heat exchanger and metal hydride alloy, must be a seamless pipe. The second shell of the designed tank, in the form of a case where the cooling liquid is located, can be made of longitudinally welded steel pipe. Based on the standard, it must also apply that longitudinal welded joints must be butt welds, of which there must not be more than one [5].

The components of the designed tank, such as the casing, which are directly part of the structure of the designed tank, and which are not subjected to pressure, must be made of steel compatible with the steel of the tank. In the case of the designed tubular metal hydride tank, the case is made of steel 1.4404/316L. At the same time, each accessory of the container must be designed in such a way as to allow inspection of the welds. The fittings must not be connected by means of longitudinal and circumferential joints and must be designed to prevent water ingress. All welds on the structure must have full penetration [5].

Before tests are carried out on the newly designed tank, it must meet the requirements mentioned in the design of the tank itself, that is, the thickness of the walls of the cylindrical part of the primary tank, the casing and the thickness of the elliptical bottoms of the tank must comply with Chapter 2 of the cited standard. At the same time, the inner and outer surfaces of the containers must be free of any defect that could make the containers in question unsafe to handle.

Standard STN EN 13322-2 describes a list of all necessary tests, namely: tensile test, brittleness test, impact test in bending, macroscopic inspection of weld cross-sections, hydraulic test on two tanks, radiographic, radioscopic or NDT inspection of welds on the structure, cyclic pressure test on one tank, corrosion test on one tank. All the mentioned tests must be carried out on the finished tanks after completion of all manufacturing processes, including cold forming at cryogenic temperature.

From a structural point of view, the most important are the cyclic pressure test and the hydraulic test until the tank breaks.

1.1 Cyclic pressure test:

This test must be performed on one manufactured tank. It must be done with a non-corrosive liquid, exposing the tank at the upper pressure of the cycle, which is equal to the maximum test pressure above atmospheric. The value of the lower pressure of the cycle must not exceed 10% of the value of the upper pressure of the cycle. The frequency of dead pressure must not be higher than 0.25 Hz, that is, 15 cycles per minute. The temperature during the test itself on the outer surface of the tank under test must not exceed a value higher than 50 °C.

The tank under test must be subjected to a minimum of 12,000 cycles without any leakage or structural failure. After the cyclic test is completed, the tank must be divided into several pieces to measure the wall thickness of the tank and at the same time to verify that this thickness is not more than 15% above the minimum thickness. The actual thickness of the tank wall must be recorded in the design test certificate.

1.2 Hydraulic test until failure:

The hydraulic failure test of the designed tank must be performed on a device that allows the pressure to be increased at a manually adjustable rate until the tank under investigation fails. When performing the test itself, the change in pressure as a function of time is recorded.

For a test pressure that is less than or equal to 60 bar, the failure pressure must be at least 2.25 times the test pressure above atmospheric. If the test hydraulic pressure is higher than 60 bar, the pressure must be 1.6 times the test pressure above atmospheric at failure. This means that the smallest possible overpressure in case of failure of the designed tank must not be less than 105.75 bar, because maximum test pressure over atmospheric is 47 bar.

No fragmentation of the material must occur during the test of the tank until failure. The main fracture after the pressure test must not show any brittleness, that is, the edges of the fracture must not be radial, they must show thickness contraction and at the same time they must be at an angle to the plane of the diameter. If the resulting fracture on the tank does not meet the above requirements, the tank must be resubmitted for further testing to decide on its acceptance or rejection.

IV. RESULTS OF HYDRAULIC TEST TO FAILURE AND CYCLIC TEST OF DESIGNED TANK

The result of the cyclic pressure test is shown in Table 1. The tank was cyclically loaded to the value of the maximum test hydraulic pressure, which was determined by the standard STN EN 13322-2 part 2. The value of the test pressure is 47 bar.

TABLE 1
RESULT OF THE CYCLIC TEST OF THE DESIGNED TUBULAR TANK

Total number of cycles (1):	15241
Average number of cycles per minute (min^{-1}):	9,15
Minimum pressure at the top dead centre of the cycle (bar):	48,6
Maximum pressure at bottom dead centre of the cycle (bar):	1,5
Maximum dead centre frequency (cycles/min):	9,5
Maximum temperature on the surface of the tank (°C):	33,2

From the test, the given tank complies with the condition set by the standard and even after 12,000 cycles, the given tank did not show any structural changes.

In Fig. 2 is the result of the pressure test until the tank breaks.

FIGURE 2: Result of hydraulic test until failure

At a pressure of approximately 500 bar, the test tank broke, which is almost 5 times of the smallest pressure for breaking the tank, which in this case is 105.75 bar. Based on the tests, it is possible to conclude that the designed tank meets the operating parameters, and it can be certified for implementation in real operation.

V. CONCLUSION

All necessary tests for certification according to standard STN EN 13322-2 part 2 were performed on the designed tubular tank. The tank successfully passed all tests, the most important of which were the hydraulic test until failure and the cyclic pressure test. Based on the results, the designed tank withstood 5 times the minimum required pressure until it ruptured and at the same time withstood more than 1200 cycles, which were determined based on the mentioned standard. The designed tank can be implemented in the real operation of the equipment, which will require a hydrogen storage system.

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Analysis of the Selected Types of Waste Treatment by Plasma Technology - Part II

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***Abstract*— *The series of articles (Analysis of the selected types of waste treatment by plasma technology. Part I., Part II.) discusses the processing of selected three types of waste using plasma technology. In this second part of the article, the processing of fly ash from municipal waste, silicone rubber and asbestos-cement material using plasma reactor technology is presented. At the end of the article, the effectiveness or the contribution of individual experiments focused on the processing of the mentioned solid wastes using plasma technology.*

***Keywords*— Plasma Technology, Fly Ash from Municipal Solid Waste (MSW), Silicone Rubber, Asbestos-Cement Material.**

I. INTRODUCTION

Plasma gasification and melting of waste commodities can be classified as a technology with wide-spectrum use of batch processing, whether from the field of metallurgy, but also various types of waste, either from the field of industry or municipal waste. The technology has been used for about 40 years. Its use is discussed in several experiments that have been published [1, 2]. Whether it is possible to talk about a universal technology for the treatment of any waste, we were convinced with the help of the plasma gasification and melting laboratory device at the Department of Energy Engineering, Faculty of Mechanical Engineering, Technical University of Košice.

II. LABORATORY PLASMA REACTOR

The experimental device of a plasma reactor with a power of 10 kVA and additional devices is presented through the table below with technical parameters (Table 1) as well as the resulting products from this technology, i.e. vitrified slag and synthesis gas.

TABLE 1
TECHNICAL PARAMETERS OF THE LABORATORY PLASMA REACTOR [3]

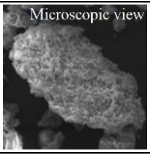
	**Volume of the reactor:**	0,006 m^3
	Operating voltage:	40 V
	Operating electric current:	250 A
	Electrical power of the source:	10 kVA
	Plasma column temperature:	1400 – 2000 °C
	Nitrogen flow rate:	5 – 8 $l \cdot min^{-1}$
	Negative pressure in the reactor:	0,2 kPa

III. PROCESSING OF THE FLY ASH BY PLASMA TECHNOLOGY

The first type of waste processed by plasma technology was the fly ash obtained from the cyclone separators of the municipal waste incinerator. Fly ash from incineration of municipal waste is a fine-grained material of light grey colour, the basic parameters of which are described in Table 2. Before the experiment itself, it was necessary to subject the fly ash to several analyses [3]:

- Determination of the percentage share of individual fly ash components,
- Determination of metal content using X-ray fluorescence spectrometric analysis,
- Determining the representation of slag-forming oxides,
- CHNS analysis.

TABLE 2
BASIC PARAMETERS OF PROCESSED WASTE – FLY ASH FROM MUNICIPAL WASTE

		**Grain size:**	0,4 – 130 µm
		Bulk density:	705 kg·m^{-3}
		Moisture:	0,46 wt. %
		Annealing loss:	10,9 wt. %
Chemical composition of fly ash in wt. %		**Metal content in fly ash in mg·kg^{-1}**	
CaO	32,50	Zn	6800,0
SiO_2	24,70	Ba	1910,0
Al_2O_3	11,90	Pb	459,0
SO_3	4,88	Cu	427,0
Fe_2O_3	4,11	Sr	406,0
MgO	2,98	Cr	329,0
K_2O	2,31	Sb	189,0
Na_2O	2,31	Zr	131,0
TiO_2	1,75	Ni	82,0
P_2O_5	1,35	V	42,0
MnO	0,18	Cd	37,0
C	1,29	As	18,0
H	< 0,02	Y	13,0
N	0,01	Mo	< 10,0
Total S.	2,30	Hg	1,4

Based on the analysis of the ash, the melting temperature of the ash in the plasma reactor was determined. The presence of stable slag-forming oxides mainly affects the determination of the melting temperature of the fly ash sample. The most dominant compounds present in the fly ash sample with high affinity to oxygen are SiO_2, Al_2O_3, CaO. By converting their percentage representation to 100% state (35,75 wt.% SiO_2 – 17,22 wt.% Al_2O_3 – 47,03 wt.% CaO) and using the ternary phase diagram SiO_2 – Al_2O_3 – CaO, we obtain the approximate melting temperature of the fly ash sample.

In this case, it was a temperature of 1450 °C, but this intersection in the ternary diagram is located at the interface of 2 areas. A small change in the composition of the fly ash can cause a shift of this intersection to the area of higher temperatures in the range of 1500 – 1700 °C, which would represent an increase in the energy demand of the process. To avoid increasing the energy demand of the process, but not to disrupt the course of vitrification, the use of a suitable flux is required.

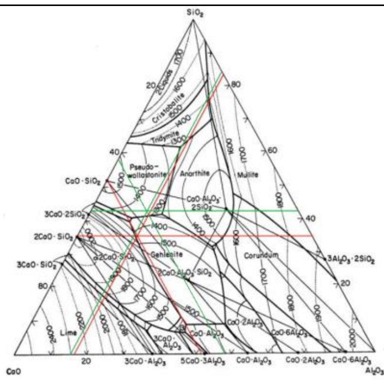
Fixation of fly ash "into the glass", more precisely into the glass matrix, is affected by the high content of alkaline CaO in the subject fly ash sample. For this reason, commonly available silica sand (alkaline flux) with a SiO2 content of 99.3 wt.% was chosen as flux. The ratio of fly ash and flux was determined from experience at 10:1.

The composition of the batch, even with the flux, after conversion to 100%, is shown in Table 3. The effect of adding flux to the fly ash sample lowered the reference melting point by approximately 100 °C, from 1450 °C to 1350 °C, as indicated by the green intersection in the ternary diagram (part of Table 3). By performing melting at a temperature increased by 50 °C, i.e. 1400 °C will be ensured:

- Formation of glassy vitrified slag (good viscous properties of the melt),
- Use of the afterburner presents in the fly ash as a reducing agent.

TABLE 3
DETERMINATION OF THE MELTING TEMPERATURE OF A SAMPLE OF FLY ASH FROM MSW INCINERATION WITH THE ADDITION OF SiO_2

Components	Percentage representation in the batch: FLY ASH + FLUX	Conversation to 100% condition
	wt. %	
SiO_2	31,49	43,83
CaO	29,54	41,12
Al_2O_3	10,82	15,06



The plasma gasification and melting experiment lasted 35 minutes at a melting temperature of 1400 °C. The charge mixture of fly ash and flux was dosed from the reservoir at 15-second intervals through a screw dosing device, while the charging time was set to 0,7 seconds based on the size of the reactor and ensuring the optimal mode of operation from the point of view of the existence of a plasma arc. A longer loading time as well as a larger amount of loaded dose would cause the loss of the plasma column, extinguishing of the arc and the end of the experiment. The process of adding fly ash was repeated until the tank was completely emptied, i.e. there were approximately 134 dosages of a batch weighing approx. 56 g. A total of 7,5 kg of the batch was remelted.

The specific energy consumption was determined to be 3,2 $kWh \cdot kg^{-1}$. The data on energy consumption is only indicative, as the heat losses of small reactors are significantly higher compared to plasma reactors with an output of several hundred kW and continuous operation.

The following products emerged from the experiment: synthesis gas and vitrified slag. The solid product from the experiment was a vitrified slag weighing 6,42 kg, with a specific gravity of 2810 $kg \cdot m^{-3}$.

The slag after tapping was allowed to cool freely in the air, then subjected to homogenization.

After its homogenization, the vitrified slag was subjected to chemical, X-ray fluorescence spectrometric analysis, ecotoxicity analysis and leachability of the slag in an aqueous solution.

TABLE 4
COMPOSITION OF VITRIFIED SLAG AS A PRODUCT OF PLASMA GASIFICATION AND MELTING OF FLY ASH FROM MSW

Chemical composition of the slag in wt. %		Metal content in the slag in $mg \cdot kg^{-1}$	
SiO_2	39,93	Ba	1570,0
CaO	32,93	Cu	1336,0
Al_2O_3	17,54	Cr	516,0
MgO	2,80	Sr	337,0
Fe_2O_3	2,79	Zn	163,0
TiO_2	1,83	Zr	136,0
P_2O_5	0,84	Pb	84,0
Na_2O	0,65	V	42,0
MnO	0,34	Ni	22,0
K_2O	0,16	Chlorides, Bromides, Y, Mo, ... < 20,0	

Synthesis gas production in the process of high-temperature gasification and melting of a mixture of fly ash from MSW and silica sand was 0,132m^3·kg^{-1} of the batch, with a calorific value of 6,16 MJ·m^{-3}.

IV. PROCESSING OF WASTE CONTAINING ASBESTOS BY PLASMA TECHNOLOGY

Another type of hazardous waste subjected to vitrification was asbestos-cement roofing. Processing this type of waste with plasma technology required the use of a flux. A flux that would be suitable for this purpose, i.e. to reduce the energy demand of the process, a waste product from coal combustion appeared, namely fly ash from fluid boilers.

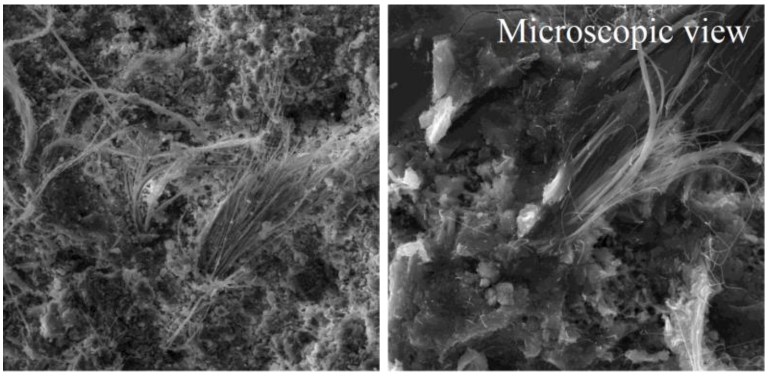
Waste that contains loosely bound asbestos (based on the structure, 2 basic forms of asbestos are distinguished – amphiboles and serpentines) are deposited in landfills after packaging (encapsulation). Covering the landfill with a sufficiently thick layer of soil is intended to prevent the leakage of fibres due to wind and water erosion. With the mentioned method of disposal of materials containing asbestos fibres, it is not possible to definitively destroy these fibres.

The samples subjected to experimental research contained asbestos fibres of the serpentine form, specifically chrysolite. As stated in the previous chapter III. it is necessary in practice to try to reduce the melting point, or of the temperature interval in which melting of debris occurs. The pure slag-forming oxides of which the slag is composed have high melting temperatures ($t_{\_m}$) [4]:

- t_{m_MgO} = 2 800 °C,
- t_{m_Al2O3} = 2 020 °C,
- t_{m_CaO} = 2 570 °C,
- t_{m_SiO2} = 1 723 °C.

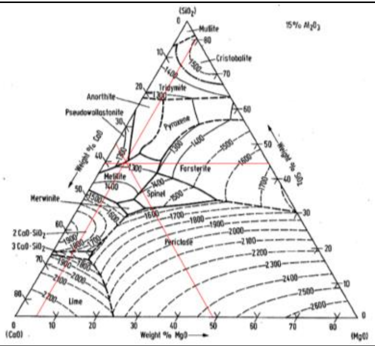
Lowering the melting point of the asbestos roofing can be achieved by adding an acidic flux to the melting process. Acidic flux (majority SiO_2 content) is e.g. the mentioned product from thermal power plants – fly ash from fluid fires of coal-fired power plants. The chemical composition of the 4 major components of the sample (asbestos and fluid fly ash) is shown in Table 5.

TABLE 5
BASIC PARAMETERS OF PROCESSED WASTE – ASBESTOS-CEMENT ROOFING (ASBESTOS) AND FLUID FLY ASH (FF ASH)

	Chemical composition of ASBESTOS in wt. %		Chemical composition of FF ASH in wt. %	
	CaO	42,50	SiO_2	44,10
	SiO_2	21,30	Al_2O_3	17,70
	MgO	5,94	CaO	7,53
	Al_2O_3	5,09	Fe_2O_3	7,28
	Fe_2O_3	2,29	MgO	1,66

The ratio of the batch mixture of crushed asbestos-cement roofing to a fraction < 5 mm and fly ash from the fluid fires of thermal power plants was 1:1. Using the quaternary diagram of the system Al_2O_3 – CaO – MgO – SiO_2, with a 15 wt.% Al_2O_3 content (Table 6), the melting temperature of the mixture was determined to be approximately 1300 °C (red intersection).

TABLE 6
DETERMINATION OF THE MELTING TEMPERATURE OF A SAMPLE ASBESTOS WITH FF ASH



Components	Percentage in the batch	Conversion to 100% status
	wt.%	
SiO_2	65,40	44,85
CaO	50,03	34,31
Al_2O_3	22,79	15,63
MgO	7,60	5,21

The experiment was carried out in two stages at a temperature of 1400 °C. The experiment was carried out in two phases under the same boundary conditions:

- I phase: tapping 5kg of melt,
- II phase: tapping 3 kg of melt.

The difference between I. and II. phase consisted in changing the cooling method of the taken sample of the resulting slag. In the first stage, the solidification of the slag sample took place by heat conduction and free convection on a concrete plate at an ambient temperature of 15 °C. In II. stage, the slag sample, after tapping into the cast iron mould, was then tipped out in the 30^{th} minute into a water bath with a temperature of 15 °C.

During the experiment (I. and II. phase) vitrified slag with a total weight of 6,903 kg was produced. The specific weight of the vitrified slag was 2875 $kg \cdot m^{-3}$. The vitrified slag was subjected to X-ray fluorescence spectrometric analysis.

TABLE 7
THE COMPOSITION OF VITRIFIED SLAG AS A PRODUCT OF PLASMA GASIFICATION AND MELTING OF THE MIXTURE – ASBESTOS-CEMENT ROOFING (ASBESTOS) AND FLUID FLY ASH (FF ASH)

Chemical composition of slag in wt. %		Content of metals in the slag in $mg \cdot kg^{-1}$	
CaO	33,50	Ba	3651,0
SiO_2	32,10	Zr	827,0
Al_2O_3	27,50	Cu	585,0
MgO	4,33	Cr	44,0
TiO_2	0,58	V	11,0
Fe_2O_3	0,31	Br, Pb, Zn, Ni, ... < 10,0	

Synthesis gas production in the process of high-temperature gasification and melting (both phases of the process) was 0,116 $m^3 \cdot kg^{-1}$ of the batch, with a calorific value of 8,205 $MJ \cdot m^{-3}$, which enables its further energy use.

Asbestos fibres in the form of chrysolite (represented in asbestos-cement roof coverings) go through various stages of recrystallization under the influence of high-temperature treatment.

The melting bpd of chrysolite fibres is high, namely 1521°C [5]. Their decomposition due to chemical reactions taking place in the melt occurs because the temperatures at the place of maintenance of the arc discharge are significantly higher than the temperature of the melt, which is monitored by a sensor at the bottom of the reactor.

The impact of vitrified slag on the environment is assessed based on the results of analyses of the leachability of the slag in an aqueous solution.

V. PROCESSING OF WASTE SILICONE RUBBER BY PLASMA TECHNOLOGY

The last type of waste subjected to plasma treatment was discarded silicone moulds used for casting processes mainly in the automotive industry or in model making.

FIGURE 1: Processed waste – silicone rubber [6]

The general properties of silicone rubber include high binding energy. The siloxane bond (-Si-O-Si-) that forms the backbone of silicone (dimethylpolysiloxane) is very stable. Compared to the carbon bond (C-C) of 355 kJ·mol^{-1}, the siloxane bond energy is 433 kJ·mol^{-1}. Compared to common organic polymers, silicone rubbers have higher heat resistance and chemical stability. The material and thermal properties of silicone rubber are summarized in Table 8, the determination of moisture, ash and combustible content was based on thermogravimetric analysis [6].

TABLE 8
MATERIAL AND THERMAL PROPERTIES OF SILICONE RUBBER

Properties	Value
Dynamic viscosity of the sample	4000 mPa·s (or cP)
Tensile strength	6,5 MPa
Extension	120 %
Shrinkage	0,2%
Dielectric strength	19,7 kW·mm^{-1}
Dielectric constant at 1 kHz	2,7
Working temperature range	–60 to +200 °C
Thermal conductivity	0,2 W·m^{-1}·K^{-1}
Combustion heat	14,39 MJ·kg^{-1}
Moisture content of the sample	0,00 wt. %
Ash content of the sample	74,34 wt. %
The combustible content of the sample	25,66 wt. %

For the purposes of the experiment of plasma treatment of silicone rubber, the rubber sample was crushed, its weight was 0,477 kg. The batch was placed in the reservoir just before the experiment was carried out. It was necessary to prevent unwanted thermal decomposition of the batch in the reservoir during the heating of the reactor.

Batch dosing was started at the desired carbon bath temperature of 1150 °C. The plasma-forming gas nitrogen was fed into the reaction chamber with a volumetric flow rate of 0.005 m^3·min^{-1}. The experiment was carried out in two phases. In the first phase, the optimal dosing interval was set for maintaining the arc discharge between the cathode and the anode.

The second phase of the waste silicone rubber recovery experiment took place in the temperature range of 1360 – 1400 °C. In both phases, the batch was dosed at a rate of 0,02 kg·min^{-1}

FIGURE 2: Inorganic residue of silicone rubber batch processed in a plasma reactor [6]

Figure 2 provides a complete idea of the success of the experiment. It is a view into the reaction chamber of the plasma reactor. A thermally decomposed charge weighing 256,36 g was identified in the lower part of the plasma reactor. It was a light grey fine-grained dust with a fine mesh structure.

In the cyclone separator of the technology and in the section between the separator and the reactor, a drift of grey-brown colour weighing 95,17 g was caught.

The samples of these solid products were subsequently subjected to thermal analysis.

TABLE 9
COMPOSITION OF SOLID PRODUCTS PRODUCED BY PLASMA PROCESSING OF WASTE SILICONE RUBBER

Component	*Mass fraction of processed waste from the reaction chamber (wt.%)*	*Mass fraction at the chimney exit (wt. %)*
SiO_2	82,7	78,04
Al_2O_3	6,74	0,09
TiO_2	4,99	0,04
Fe_2O_3	1,29	0,23
Na_2O_3	1,29	< 0,01
K_2O	0,63	0,02
CaO	0,47	0,15
P_2O_3	0,18	18,1
MgO	0,14	0,02
SO_3	0,10	0,05
MnO	0,06	0,03
Annealing loss	1,08	3,4

The high representation of SiO2 in waste solid products is the result of thermal decomposition of the main siloxane bond, in which silicon, characterized by a high affinity for oxygen, oxidizes to SiO2. The presence of phosphorus and titanium can be explained by the presence of colorants, vulcanizing agents and other additives in silicone rubber.

VI. CONCLUSION

The conducted experiments can be considered successful. In all cases of thermal treatment by plasma technology at high temperatures in a nitrogen atmosphere, the processed batch was decomposed into gaseous components and a solid residue in the form of chimney waste or product in a plasma reactor, or in the form of vitrified slag.

The energy recovery of the produced synthesis gas would be possible in all cases, but it is important to clean it before the actual use process. The calorific value of the produced synthesis gas for all types of input waste is shown in Table 10:

TABLE 10
AVERAGE CALORIFIC VALUE OF THE PRODUCED SYNTHESIS GAS

Waste batch for plasma treatment	The average calorific value of the produced synthesis gas in $MJ \cdot m^{-3}$
Fly ash from municipal waste	1,628
Asbestos-cement roofing	8,000
Silicone rubber	5,240

In the case of plasma processing of silicone rubber, the production of chimney waste represented an unexpected problem, i.e. the weight of the chimney waste to the weight of the batch was 20 wt. %. Chimney waste was mostly deposited in the chimney space of the reactor, and its deposition in some places caused almost 100% of the cross-section of the pipe system to be clogged.

From laboratory analyses in the case of vitrified slag as a product of plasma processing of fly ash from municipal solid waste and waste asbestos-cement roofing, it can be concluded that the vitrified slag represents inert waste without its further negative impact on the environment.

Only what concerns the plasma processing of silicone rubber, under the marginal conditions valid for the given experiment, is unjustified from an economic and ecological point of view. The processing of silicon waste in a plasma reactor does not exclude the formation of toxic products released during the chemical reactions occurring in the process of thermal decomposition of the batch. However, if the marginal conditions are changed, it is not excluded that the processing of silicone rubber by plasma technology would not bring the desired results for a more ecological solution for the disposal of this type of waste.

ACKNOWLEDGEMENTS

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Design of a Heat Exchanger for A Tubular Metal Hydride Storage Tank using Air as A Cooling Medium

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***Abstract*—** *The article in question deals with the issue of cooling the designed tubular metal hydride storage tank with the use of active and passive cooling modules, which are implemented in the designed storage tank. The passive module used in the tank is realized by means of an aluminium heat transfer intensifier, which is placed directly in the metal hydride alloy of the tank, and as an active cooling module, air at a temperature of 10 °C is considered, and in the second simulation, an air temperature of 30 °C is considered.*

Keywords*— *Metal hydride, pressure tank, hydrogen.

I. INTRODUCTION

Sustainable energy conditions all aspects of the functioning of modern society. A fully integrated and well-functioning internal energy market is an essential part of a sustainable national economy, the gradual transformation of which into a system characterized by a significant degree of carbon neutrality is currently highly relevant. Achieving a balance between carbon emissions and their absorption by natural systems requires a significant shift away from the use of fossil energy sources, a rapid increase in the share of renewable energy in total energy consumption, the continuous development of ecological technologies with a view to increasing their efficiency, and the use of climate-neutral energy carriers such as hydrogen.

For hydrogen to become a real alternative to fossil fuels in the long term, it is necessary to look not only for ecological non-fossil sources for its production, but also for efficient systems enabling its long-term and safe storage. Hydrogen storage is a very important component of the hydrogen economy system [1]. Currently, there are many ways to store hydrogen in the world, but the most common storage methods are through compressed gas or high-pressure storage, liquid storage of hydrogen through cryogenic temperatures or based on absorption into a metal alloy or low-pressure hydrogen storage. Hydrogen in the absorption method of storage forms metal hydrides with metals and alloys, which in some cases have a higher storage density than storage in pressure and cryogenic vessels. Storage in metal hydrides is a safer and volume-efficient form of storage. A metal hydride is formed by a host metal lattice and hydrogen atoms. However, this type of storage has its disadvantages, the biggest disadvantage being its weight within the system and at the same time the need to remove the generated heat during the exothermic reaction of hydrogen and metal hydride.

The article in question deals with the design of a heat transfer intensifier for efficient removal of the generated heat from the core of the tubular tank and subsequent cooling of the tank by means of a cooling medium located in the space between the primary tank in which the metal hydride is stored and the outer shell.

II. STRUCTURAL DESIGN OF A TUBULAR METAL HYDRIDE STORAGE TANK WITH AN INTEGRATED COOLING SYSTEM

The design considers a tubular tank, the diameter of the inner container with a metal hydride alloy is 60.3 mm. The dimensions of the tank, such as thickness, length and other dimensions, were determined based on the STN EN 13322-2 standard. The thickness of the tank wall is 2.6 mm. There is a metal hydride alloy inside the tank and a passive heat exchanger or heat transfer intensifier. On the surface of the tank shell, heat removal is ensured by means of a ribbed heat exchanger, where the heat is then removed from the surface of the ribs to the surrounding environment. In this cooling model, free convection is considered. In the design of the heat transfer intensifier, cross lamellas are considered, which gradually expand from the main axis. The primary lamellas of the intensifier describe a circle and the gap between the inner wall of the tank and the fin of the intensifier is 0.5 mm. The side secondary fins have a thickness of one millimeter, the length of which is from 7 to 12 mm. There are 6 primary fins and 18 secondary fins within the heat transfer intensifier system. In Fig. 1 shows the designed heat transfer intensifier in the cross section of the tank

Where: red colour represents the steel shell, brown represents the metal hydride alloy, and grey represents the internal heat exchanger

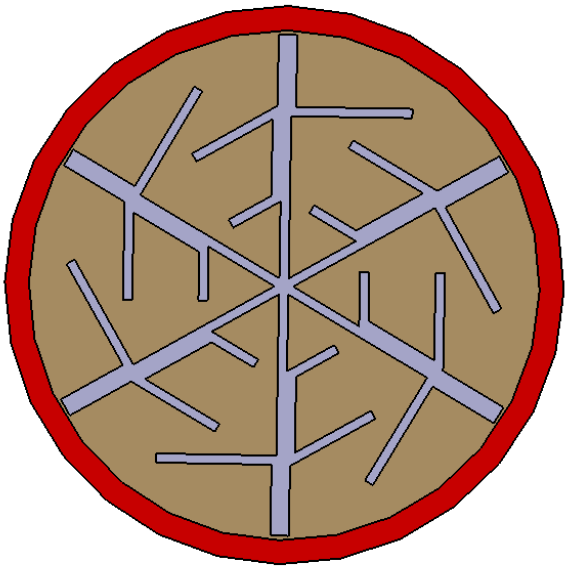

FIGURE 1: Designed heat transfer intensifier inside a tubular metal hydride tank

For the simulation, it is necessary to prepare a simulation model and therefore it is necessary to associate the external ribbing model with the model. The simulation model is shown in fig. 2.

Where: blue colour represents external ribbing

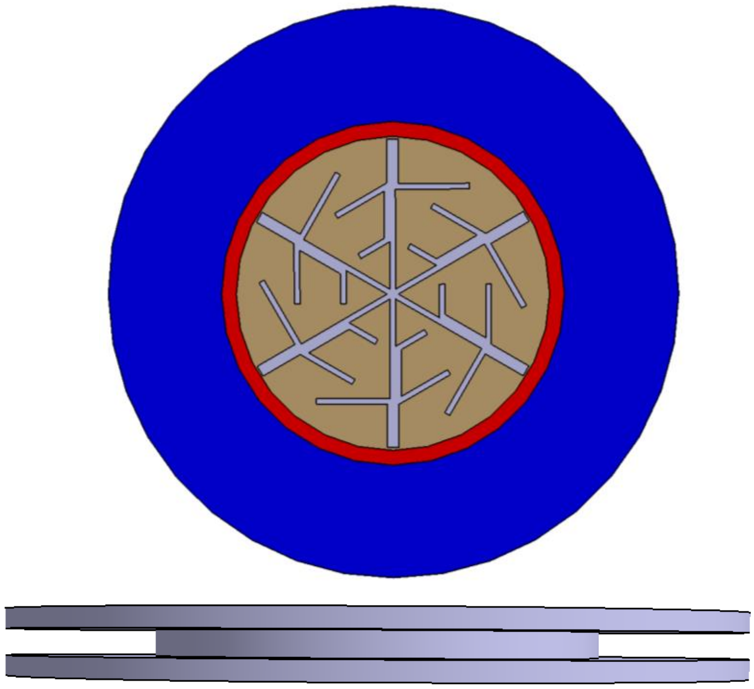

FIGURE 2: Simulation model of the system using an internal heat exchanger and a section of a part of the external ribbing

III. HEAT TRANSFER SIMULATION OF THE DESIGNED TANK USING THE CFX PROGRAM

In this section, the heat transfer simulation of the designed tubular storage tank is explained in detail, which uses an internal passive heat exchanger and uses an external finned system located on the outer wall of the storage tank shell. The cooling system is made of aluminum, the steel tank is made of stainless steel 316L. The tank contains a TiFe-based metal hydride alloy of the brand Hydralloy C5, whose maximum storage capacity is at the level of 1.8% wt. at room temperature. The simulation is set to 1200-time steps, where each step represents 10 s. The time 1200 s also represents the time of filling the tubular tank with hydrogen. Another condition that needs to be defined in the simulation is the power of the generated heat during the process of hydrogen absorption into the metal alloy structure.

To determine the power of the internal source of generated heat, the following equation must be used:

$$P = \frac{Q}{V \cdot t} \qquad (W \cdot m^{-3}) \tag{1}$$

Where: P- performance of the metal hydride alloy in the tank ($J \cdot m^{-3}$), Q- heat generated during the absorption of hydrogen into the metal hydride alloy (J)- 1 MJ of heat is consumed for 1 m^3 of stored hydrogen in the case of the designed tank, that is 0.5698 MJ, V- the volume of the metal hydride alloy (m^3) in the case of the designed tank, that is $1.18 \cdot 10^{-3}$ m^3, t- the time of filling the tank and this represents 1200s.

The intensity of the internal source of generated heat is therefore determined to be 401,730 $W\text{-}m^{-3}$. To simplify the simulation, the heat transfer coefficient on the surface of the outer ribs is determined by means of criterion equations for free convection, and the value of the coefficient is set to 25 $W \cdot m^{-2} \cdot K^{-1}$. The outside air temperature as a cooling medium was initially set to 10 °C and in the second simulation to 30 °C. The use of air as a cooling medium reduces the overall requirements for the design of the tank because, for example, if water were used as a cooling medium, it would be necessary to make a double-walled tank to create an intermediate space for water as a cooling medium, which would significantly increase the total cost of production. In the first simulation, it was considered without the use of the heat transfer intensifier, and the result of the simulation is shown in Fig. 3.

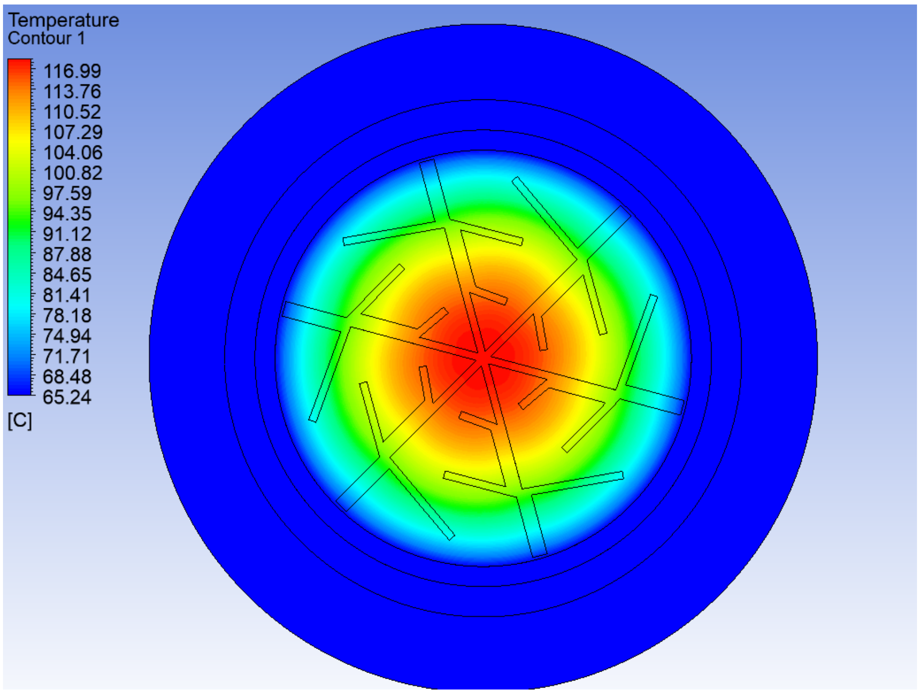

FIGURE 3: Generated temperature fields after 1200s of filling with hydrogen at an external temperature of 10°C without an internal heat transfer intensifier

The generated temperature in the tank without an internal heat transfer intensifier range in very high values up to 117 °C and thus the metal hydride alloy would not be able to absorb hydrogen into its structure because the limit temperature for absorption is approximately 75 °C.

In the second simulation, an internal heat transfer intensifier is applied, and the result of the simulation is shown in fig. 4.

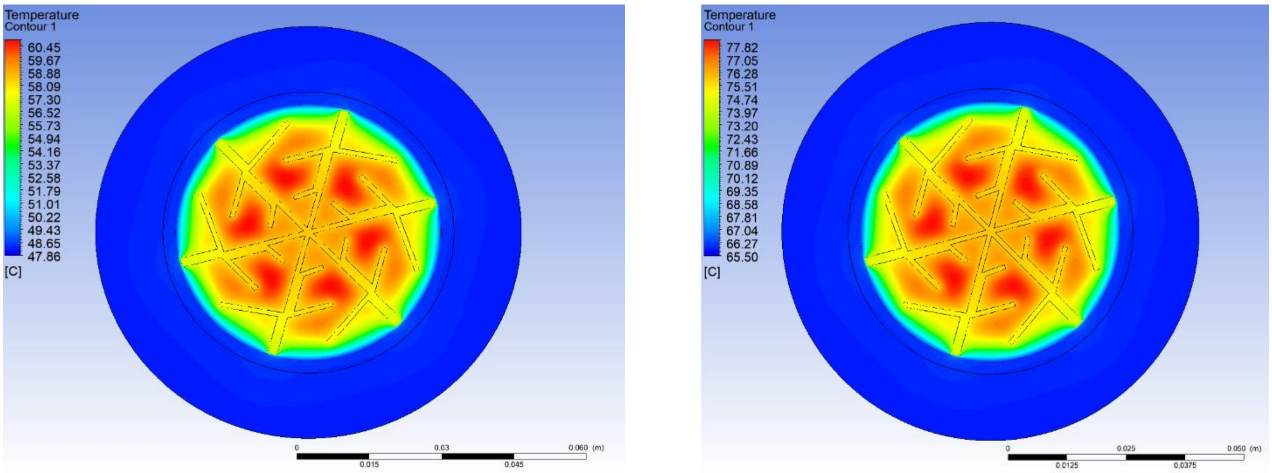

FIGURE 4: Generated temperature fields after 1200s of filling with hydrogen at an external temperature on the left side of 10 °C and on the right side of 30 °C with an internal heat transfer intensifier

The next step is to display the course of maximum temperatures in the tank during the process of filling the tank with hydrogen. Temperature curves are shown in Fig. 5.

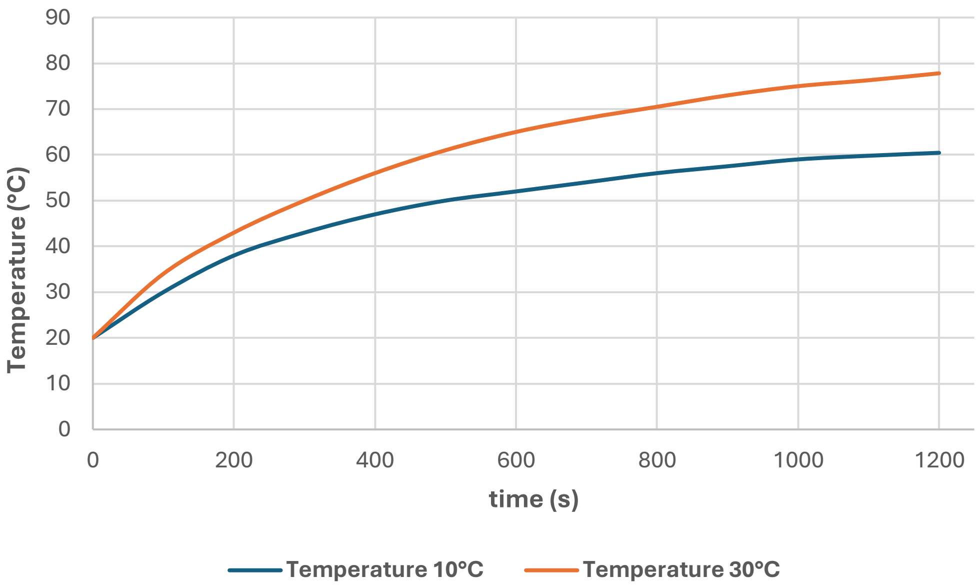

FIGURE 5: Course of maximum temperatures during the process of hydrogen absorption into the metal alloy structure at cooling air temperatures of 10 °C and 30 °C

Fig. 5 shows the temperature courses in the time interval 0 - 1200s when using an internal intensifier with cross-lamellas and an external heat exchanger ribbing. From the initial temperature of 20°C, the temperature of the tanks gradually increased according to the temperature of the cooling air to a temperature of 61°C at 10° C cooling air and to a temperature of 78 °C at 30 °C cooling air.

In the case of the use of outside ribs, it is also possible to observe the heat flow (Fig. 6) influenced by the presence of the individual ribs of the intensifier, but a more significant homogenization of the heat flow already occurs on the ribs.

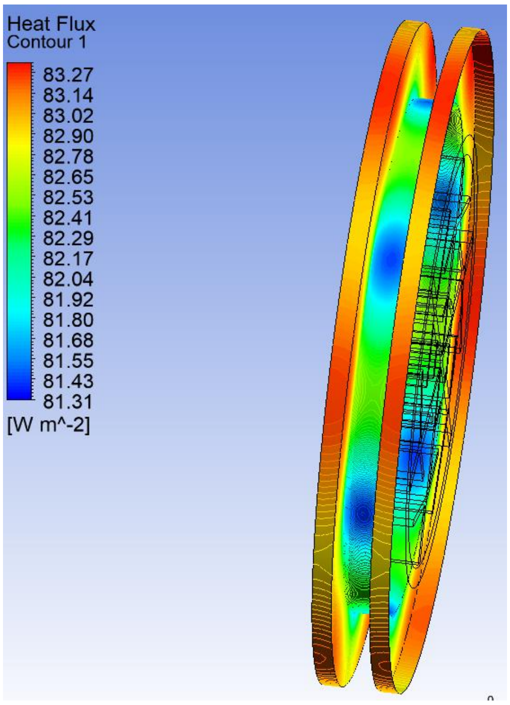

FIGURE 6: Heat flux of outside ribbing system

From the course of the simulations, it is obvious that without the presence of an intensifier in the tank, overheating of the core occurs, while the heat flow from the core to the surroundings is impaired, due to the powder structure of the metal hydride alloy. With the use of an internal heat transfer intensifier, in the case of an air-cooled tank, the heat distribution was stabilized within the entire cross-section of the tank, and the maximum temperatures generated on the tank comply with the operating parameters, as the limit temperature for the absorption of hydrogen into the structure of the selected metal alloy is 75 °C.

IV. CONCLUSION

The subject of this article was the creation of an efficient cooling system using the active cooling medium of air through external fins that were placed on the outer wall of the tank. The maximum temperatures during the process of absorption into the structure of the metal alloy at an air temperature of 10 °C created temperature fields of the metal hydride alloy at the level of 60 °C, and at an air temperature of 30 °C the temperature fields were at the level of 78 °C, which represents the limit temperature for the absorption of hydrogen into structure of the selected metal hydride alloy and thus it can be concluded that it meets the operating parameters. Based on the simulation, it is also possible to conclude that for the cooling of the tank system designed according to the STN EN 13322-2 standard, the use of external fins for cooling the system is completely sufficient, which reduces production costs.

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AI for Development is a Malapropism

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Abstract— *Artificial Intelligence (AI) has increasingly been included in the range of enabling technologies and tools that support and streamline the process of Development. This led to the promotion of domains such as AI for Good, AI for the Poor or AI for Development (AI4D). But, doing so, it is implicitly assumed that AI complies with the distinctive features of ICT4D such as affordability, relevance, openness and ownership. In this paper, it is shown that AI does not fulfil most of these characteristics and that the term AI4D does not seem to be grounded. To a certain extent, the use of this acronym is misleading and against the fundamentals of the Technology for Development. Decision makers in developing countries shall ponder all factors related to the use of AI and embrace a wider perspective in elaborating and sustaining their national digital transformation strategies.*

Keywords— Artificial Intelligence, AI4D, ICT4D, Technology for Development, National Digital Transformation Strategies.

I. INTRODUCTION

Actors involved in ICT4D (Information and Communication Technology for Development) can be naturally tempted to include Artificial Intelligence (AI) in the range of enabling technologies and tools that may support and boost the Development process. This may be a legitimate expectation. Yet, promoting AI for Development (AI4D) raises numerous problems since it assumes that AI complies with the very specific features of the ICT4D context, including, among others, affordability, relevance, openness, and ownership. Unfortunately, today's AI fulfils none of these, and the enthusiastic posture that AI4D is a natural part of ICT4D is not grounded and, to a certain extent, does not serve the purpose of Technology for Development.

With the purposes and goals of today's AI technology, it is difficult to elaborate a research proposal where an AI application/tool is used to primarily serve the purpose of Development, without explicitly admitting (and contributing) to some amalgamations and/or maline abstractions, including: technology misconception, mixing the application domain and the technology type, stating/defending general human rights, social and societal values and principles, and how technology could support these, regardless of whether this technology is ICT4D or not.

Considering the current race that takes place in developing countries and aims at elaborating digital transformation strategies using AI as a core technology (Government of India, 2018), it is timely and useful to (re)put things in the appropriate context, and define/understand their meaning, contrast them, and conclude as to how fit these are within the Development context and constraints. It is not healthy to adopt a technology just because it is new and/or because vendors pretend it can solve all our problems. Rather, we believe that policymakers (in developing countries, particularly) should concentrate on the actual needs (of the country and the population) and to define them independently of any specific technology nature or type. Then, they could prioritize ICT4D (Model, Techniques and Tools), as the main enabler for the digital transformation process of their countries.

II. INFORMATION AND COMMUNICATION TECHNOLOGY FOR DEVELOPMENT

The ICT4D theory is grounded in the notions of "development", "growth" and "progress", and is often interpreted as the use of technology to streamline and boost the process of development in developing countries (Heeks 2017) (Zheng et al. 2018). Because of their ubiquitous nature, ICTs are being used everywhere to do almost everything, quickly and accurately. Today, the automation spectrum is so large and deep that there isn't a single human activity that is not impacted, one way or another, including: schooling, trading, gaming, chatting, etc. Wealth has been increasingly generated and maximized via flows of information, data, and knowledge, in a "globalized" World, and ICTs' continuous advances, expansion and adoption led to structural transformations in the economy landscape, with inequalities that widened and widened between individuals, communities and countries, leading to what is known as the digital divide, which is the gap between countries with an effective access to/usage of digital and information technology and those with very limited or no access/usage at all (Norris, 2001).

The digital divide is closely related to the knowledge divide since the lack of access to ICTs makes the access to information and knowledge a real challenge. Several studies also showed that the digital divide is linked to other human development divides (Norris, 2001). They pointed out two contradictory facets of technology: a "positive" facet enabling the boosting of economy, business and public administration, and a "negative" facet consolidating the digital divide, the isolation of regions/populations and degradation of their life conditions (Unwin 2017).

Research on ICT in developing countries emerged in the 1980s, with studies of computer diffusion in various countries and studies of government policy about the use of computers in various sectors. Early researchers of what came to be known as 'ICT for development' (ICT4D) shared the belief that computers can solve many of the severe problems confronting developing economies and societies, such as grossly inefficient government administration, inadequate provision of health care and education and inability to compete in a global economy (Avgerou 2017). The interest in correlating ICTs and Development started around the eighties of the last century, when the International Telecommunication Union delivered a commissioned report entitled "The Missing Link" which noted the urgent need to pursue telecommunication reforms in order to extend the coverage of telephony (and its effects) and thereby, address the "telecom divide" (ITU, 1985). Progressively, global institutional efforts elevated Information and Communication Technologies for Development (ICT4D) to the forefront of the international agenda. ICT4D refers to the application of computer mediated technologies toward social, economic, and political development, with a particular emphasis on fighting the digital divide, helping poor and marginalized people and communities.

Unlike "mainstream ICTs", where the main goal is to create software for business purposes, ICT4D is about what should be done to support human and socio-economic development, and how to do it. It is not about the technologies themselves, but is concerned, rather, with how these can be used to empower poor and marginalized communities (Heeks, 2009). This implies that technologies, platforms and tools that are used in ICT4D must fulfil some largely agreed-upon features such as affordability, relevance to development, accessibility, openness, customizability and ownership. A comprehensive description of these specific ICT4D features is included in (Kettani and Moulin, 2014) and in (Avgerou, 2010). An ICT4D Tool/Technology may not fulfil all ICT4D specific features but, necessarily, it must fulfil some of these without compromising the rest.

III. ARTIFICIAL INTELLIGENCE FOR DEVELOPMENT

The field of Artificial Intelligence (AI) has been around for more than 80 years, as a sub-field of Computer Science. AI aims at building 'intelligent agents' and devices to mimic tasks that are naturally associated with humans (McCarthy, Minsky, Rochester & Shannon, 1955) such as understanding, reasoning, searching, seeing, singing, thinking and talking. To perform these tasks, such devices (programs, bots, robots) must have some knowledge about the world in which they evolve and how they can manipulate it to perform useful tasks. Up until recently, these actions/functions were exclusively associated with humans, as a kind of cognitive feature demonstrating the superiority of humans over machines. Hence, these cognitive activities were not parts of common computer functionalities!

In the 1950s Alan Turin, one of the fathers of AI, proposed and designed the famous Turing Test (Turing, 1950). The aim was to provide a tool for assessing if a machine was able to exhibit an 'intelligent behaviour'. The idea was to determine if a machine can mimic human intelligence in an interaction with a human using natural language so that communication could be indistinguishable from interactions between humans. The Turing test does not commit on the nature and structure of the reasoning process performed by the machine.

Many researchers suggested that an AI agent should not only act "humanly", but also, and more importantly, that it should use "human thinking" in the process of producing the intended outcomes/results. But what is "human thinking"? How is it linked to intelligence? Where does it come from? How does it apply in/to the context of automation and agent programming? Is intelligence exclusively related to mathematical and logical deductions and inductions, or is it rather more about heuristics, intuition, learning, understanding, discovering, awareness, etc.? Up until now, there has been no formal/specific agreement among the AI community on these important issues, leading to some "uncertainty" surrounding the nature, scope and role of

AI systems. And, because of such uncertainty, the AI field went through several ups and downs, during the past 70 years or so (Russell & Norvig, 2021). The last AI hype that is still in progress, is with no surprise among these.

Thanks to the considerable performance increases in the CPU and GPU and to the huge data sets made available through business records, individuals' profiles and data obtained from social media, the use of AI has significantly accelerated over the last 10 years, especially in areas such as client support, natural language interactions (and communication in general), vision/image recognition, process optimization, and fraud analysis on transactional data. As their main computing technique most of these applications use either Machine Learning or Deep Learning (or a combination of both). Such techniques (stochastic, linear, or probabilistic) are purely quantitative with no intuition and/or common sense involved in them. The denomination "Weak-AI" has been attributed to the current AI hype to denote its limitation in terms of the AI theoretical foundations and its task-specific orientation (Searle, 1980). Moreover, "Strong-AI" emphasizes the creation of machines with cognitive capacities comparable to human intelligence (Searle, 1980). It involves the effort to replicate human understanding, reasoning, learning, and problem-solving across multiple areas. Strong-AI seeks to create robots with the goal of replicating the whole range of human cognitive capacities.

The United States Agency for International Development (USAID) was amongst the first to advocate for the use of *AI for Development* (USAID 2018). Loosely equating ML with AI, the agency claimed: "ML and AI have a tremendous potential for helping to achieve sustainable development objectives globally. They can improve efficiency by automating labour-intensive tasks, or offer new insights by finding patterns in large, complex datasets".

The International Telecommunication Unit (ITU) defines AI for development (*AI4Dev*) as a challenge that aims to identifying great ideas in Artificial Intelligence and utilizing its impact on Sustainable Development Goals (SDGs), in developing and less developed countries [1]. The ITU developed an action-oriented, global & inclusive UN platform, *AI for Good*, with the goal of identifying practical applications of AI to advance the United-Nations' Sustainable Development Goals (SDGs) (United-Nations 2015) and scale those solutions for global impact on [2].

The United-Nation Development Program (UNDP) considers that AI for development is fundamentally about people. Applications of AI for development need to be led by lives and livelihoods, not just data points and digital [3]. Putting people at the centre of AI thinking, piloting and scaling is a crucial foundation of the AI4D approach at UNDP.

The term AI4D used by these agencies suggests that there is some substance of AI that is properly and exclusively dedicated to Development, or that it is more/better fit for the Development context. Juxtaposing the "D" next to "AI" implies, as well, that there is some complementarity between the two fields, or some affinity that goes without saying, or an obvious added value that is mutually applicable. However, we need to emphasize that, regardless of whether we look at AI from the Strong-AI perspective or from the Weak-AI perspective, the AI concerns and fundamentals, as we briefly introduced them earlier in this paper, have nothing to do with International Development, and International Development has never been an issue in (and for) AI.

If we consider AI technology, from the "Strong" perspective, with the ultimate goal of computerizing human cognitive abilities in order to "manufacture" machines/devices with comprehension, adaptability, and an independent thinking level equivalent to humans, one will find it complicated (otherwise impossible) to relate Strong-AI to ICT4D, or to International Development in general.

If we consider AI technology from the "Weak" perspective which applies to current AI technologies, the unfitness of AI for Development is blatant for many reasons, including:

The lack of generalization, adaptability and comprehension, outside the specific set of tasks/fields where the AI technology is applied, including (but not limited to) chatbots, profiling, imagery, search and assistance. Adopting AI necessarily means using it to solve a problem within the range of this specific set of tasks. At the level of countries, this triggers the risk that decision makers may alter their current digital transformation needs for the country, with unjustified needs related to the specific tasks/fields AI solves;

a) The inability to handle unforeseen conditions/situations leading to endless reprogramming and interventions by AI vendors/consultants. At the level of countries, this means increasing their dependency relative to the AI Industry, and weakening their autonomy;

b) The lack the “explainability” is another main problem of current AI systems because they are not able to justify their recommendations with arguments and explanations that a human legitimately needs to accept and understand and the proposed actions. Indeed, Weak-AI Systems do not have the ability to explain their decisions and the proposed scenarios, and using them at the level of countries, increases the risk of empowering autocratic and authoritarian governance systems and weakening citizens’ participation and involvement;

c) It is obvious that the AI technology stack is an expensive one, which is against the affordability and openness features of ICT4D;

d) AI is essentially data driven, which means that the systems are trained and have learnt what they” know” to do thanks to huge amounts of data that have been accumulated in gigantesque data stores, over decades and decades of time, through a considerable effort of digitalization, analysis, structuring, standardization and normalization of real worlds “things” and “situations”. Financial data sets include, for instance, how banks have processed loan requests of their clients, over the last 50 years, and what were the corresponding decisions (to grant the loan or not, following the client profile), and how were these decisions fit or unfit with respect to what actually happened with every single client and every single loan request (has the loan be reimbursed, has there been any difficulty, etc.). Justice data sets include how judges and tribunals have processed the cases, what the verdicts were and whether these verdicts were fit or unfit. By analogy, we can use these 2 examples to imagine the type, nature and volume of data that is needed to use AI in highly social sectors such as Education, Health, Culture, etc. give an idea about that the data AI systems use/need. Clearly, in most countries of the world, and in particular in developing countries, the data that AI requires does not exist and would need decades of hardship to be elaborated and readied. The suggestion that AI systems’ decisions are data independent is simply a fallacy. The lack of enabling data means simply that AI is not possible in the context of Development;

e) Black-box oriented architecture means that AI systems do not allow to know how they are internally organized, structured and programmed. The current hype is about ‘Deep Learning’, but that does not mean that programmers know better how the system is adjusting its parameters and internal data (weights of neural nets)! Hence, people should faithfully use AI systems, as they are, but one can never own them, master them, or produce/manufacture them. In the ICT4D Context, where countries are highly encouraged to develop their local capacity, to master technology and to contribute to the society of knowledge, the adoption of AI is simply not fit;

f) AI tools and solutions are mainly cloud-based; which means that most of the hardware, software and data that form the system, and that is needed to run it, are located somewhere in the world, that you don’t know of. As data and information are the heart of any governance system, having these located remotely, with the associated risks (corruptibility, loss, disruption, etc.) is simply against the sovereignty of countries and their regalian attributions.

Finally, if we forget about the distinction between Strong-AI and Weak-AI, and we try to use AI just like any other technology tool/application, today’s AI appears more as a harming and disturbance element rather than a simple/normal enabling technology for Development! This is, among others, due to a high pressure put by vendors (and some development agencies) on decision and policy makers using magical headline such as: “AI is here to solve all your problems, just but need to buy!”. If you transpose this headline to the general audience language/understanding, this will likely read “if you don’t use AI, you are not a good decision maker!”. At the level of regions and countries, this reads “if you don’t use AI, you are not using the right tools to support/enhance your governance process!”. This unhealthy pressure has numerous consequences, including:

a. Biasing the choice of the right technology to use;

b. Disturbing and delaying (again) the implementation of national digital transformation strategies;

c. Spending (a lot of) money with no impact on the Development process;

d. Introducing more doubt, perplexity, and fuzziness among decision and policy makers;

e. Widening, again and again, the digital divide.

IV. CONCLUSION

During the past decade, through slogans such as *AI for Good*, *AI for the Poor* and *AI for Development* (AI4D), AI has been strongly promoted to support and accelerate Development. This ‘AI frenzy’ may potentially overshadow the continuous efforts needed to sustain ICT4D in developing countries, at least in the mind of citizens and of policy and decision makers.

In this paper, we shed some light on an important aspect that seems to be forgotten in the current AI4D promotion: the principle that using any technology in ICT4D should first promote/support Development and contribute to good governance in general. We highlighted the contrast between the nature and purpose of AI, and its purported revolutionary use as an ICT4D technology. Although, at first glance, AI4D seems comparable to ICT4D, we showed that the analogy does not stand.

Artificial Intelligence, as a field of knowledge, is undoubtedly interesting and exciting! It has great potential, but it does not particularly fit in the context of Development and is not inherently *ICT4D Compatible*. ICT4D is different from ICT, and from AI, taken alone. The difference does not only encompass the context, specifications and methodologies that are strongly linked to Development, but they shall fulfil specific requirements derived from the development context including, among others, affordability, openness, relevance, ownership, understandability and explainability. We showed that current AI applications do not comply with these requirements. As an alternative, we *propose a vision that* fosters ICT4D thanks to the wise use of relevant AI applications, in the same way as any other enabling technology. We believe that in the context of development, this vision is a better fit and more reflective of what (and how) to conceptualize the benefits of the AI technology, without compromising the ICT4D fundamentals. We are currently working on a methodological framework to accompany policy and decision makers who would like to adopt such a vision

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