İstanbul GEDİK University

International Journal of Engineering and Natural Sciences

IJENS's

Vol:2 - Issue: 2
Year : 2019

International Journal of Engineering and Natural Sciences (IJENS), Vol. 2, No. 2

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International Journal of Engineering and Natural Sciences (IJENS’s)
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Analysis of Different Engine Types in Aircrafts with Exergetic Approach

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Abstract: The main purpose of exergy analysis is to determine the maximum possible work that can be obtained and to decrease inefficiencies on the system. Exergy analysis provides information about the intensity and positions of inefficiencies. In literature, there are studies for different purposes, types of engines and aircraft, both civil and military. In this work, many different studies were taken as basis. A total of five different types of turbofan, turboprop and turboshaft engines have been analyzed in terms of energy and exergy. First, information has been given about selected engines, technical specifications and usage areas. Next, general thermodynamic analyses and their details are presented. In this context, general and thermodynamic working principles of the aircraft engines have been identified. Then, these identifications have been extended for each of the engines and the thermodynamic analyses as well. Indications are shared with the help of general assumptions. In the final section, results of all studies and data are presented.

Keywords: Aircraft, exergy analysis, turbofan engine, turboprop engine, turboshaft engine, exergy efficiency, inefficiency.

1. INTRODUCTION

Airline transportation is crucial to become a global market in consequence of economic developments. Especially as the demands on speed, safety and comfort increase, transportation systems also show the same improvement; thus, both countries and companies have increased their investments in these directions. Since Turkey has an important geographic position, passenger numbers increased from 34 million in 2003, to 193,3 million in 2007 in total [1- 3].

Globally, energy consumption and efficient use of energy sources is of great importance. The main purpose of studies in this direction can be generalized as ensuring correct usage of resources, sustainability and decreasing costs [7].

When examined thermodynamically, thermal systems have to obey both the First Law of Thermodynamics (energy conservation) and the Second Law of Thermodynamics (exergy analysis, utility). analysis, utility). The First Law of Thermodynamics is also named as “law of energy, the energy conservation” and this law clarifies the balance between the work that system applies to its environment and heat rate that is accrued to the system. Energy analysis is concerned with the system quantity and does not take into account losses when irreversibility happens. The Second Law of Thermodynamics gives the information of entropy production during the state changes of the system, decrease of energy quality, and utilization of the capability of work in system. While some of the exergy in the system is disappearing because of the irreversibilities, others are dumped to the environment from system’s boundaries [8].

By the transformation of actively used types of energy such as wind, electricity and aircraft engines, different forms of both sustainability and providence are achieved. Especially aircraft engines are studied thermodynamically, revealing new progress due to their capacity of high-rate energy productivity. Aircraft engines are commonly classified into three main categories as turbofan, turboprop and turboshaft [7].

Turbofan engines, which are also known as “fanjet”, are the combination of fans and turbines. The biggest difference of fanjets from turboprop engines is the by-pass ratio, which is also known as the “air flow ratio”. Turbofans are divided into two sub-categories as “low by-pass ratio” and “high by-pass ratio”. Low by-pass ratio turbofan engines are preferred in civil aircraft due to their performance in long haul flights by producing high thrust, low volume and their compact bodies.

Turboprop engines are not capable of producing a high rate of energy; so, most of the produced energy is used to rotate propellers. In contrast of turbofan engines, turboprop engines are more productive in low speeds.

Turboshaft engines are the types of engines which show properties like high power output, high reliability, small body-size and light body-weight. In general; turboshaft and turboprop engines have common working principles. The difference between turboprops and turboshafts is the mechanic part that transfers energy [4].

2. THEORETICAL ANALYSIS

Before making thermodynamic analysis of a system, defining thermodynamic terms in the system and their main components are important and beneficial for further study.

Total exergy amount in a system is equal to summation of physical, chemical, kinetic and potential exergies [2- 9].

$$\varepsilon = \varepsilon_{kn} + \varepsilon_{pt} + \varepsilon_{ph} + \varepsilon_{ch} \tag{1}$$

$$\varepsilon_{kn} = \frac{V^2}{2} \left(\frac{m}{s}\right)^2 \left(\frac{1kJ/kg}{1000m^2/s^2}\right) \tag{2}$$

$$\varepsilon_{pt} = gz \left(\frac{m}{s^2}\right)(m)\left(\frac{1kJ/kg}{1000m^2/s^2}\right) \tag{3}$$

$$\varepsilon_{ph} = \left[(h - h_o) - T_o(s - s_o)\right] \tag{4}$$

$$\bar{\varepsilon}_{ch} = -\bar{R}T_o \sum x_k \ln \frac{x_{o,k}}{x_k} \tag{5}$$

$$\bar{\varepsilon}_{ch} = \sum x_k \bar{\varepsilon}_{ch,k} + \bar{R}T_o \sum x_k \ln x_k \tag{6}$$

Total energy amount in a system is equal to summation of physical, chemical, kinetic and potential energies, just like exergy [2- 11].

$$e = e_{kn} + e_{pt} + e_{ph} + e_{ch} \tag{7}$$

$$e_{pt} = gz \left(\frac{m}{s^2}\right)(m)\left(\frac{1kJ/kg}{1000m^2/s^2}\right) \tag{8}$$

$$e_{ph} = u + Pv = c_{P(T)}T = h_{(T)} \tag{9}$$

$$e_{kn} = \frac{V^2}{2} \left(\frac{m}{s}\right)^2 \left(\frac{1kJ/kg}{1000m^2/s^2}\right) \tag{10}$$

$$e_{ch} = H_a + h_{(T)} = H_a + c_{P,F,i}T_i - c_{P,F,o}T_o \tag{11}$$

$$e_{ch} = H_u + h_{(T)} = H_u + c_{P,F,i}T_i - c_{P,F,o}T_o \tag{12}$$

With the help of above equations, derivations for components of aircraft engines can also be carried out. The schematic description of low by-pass rate JT8D turbofan engine and some typical terms are explained below mathematically [11]. Calculation of main components of AE3007H engine were done as well, but now shown in this paper.

General exergy balance equation [11];

$$\sum \dot{E}x_{t,in} = \sum \dot{E}x_{u,out} + \sum \dot{E}x_{w,out} + \sum \dot{E}x_{dest,out} \tag{13}$$

where $Ex_{t.in}$ is the chemical exergy of fuel that is burned in the combustor, $Ex_{u,out}$ is the useful exergy output, $Ex_{w,out}$ is the waste exergy output and $Ex_{dest,out}$ is the output of exergy destruction.

Waste exergy equation is as follows [11];

$$\dot{E}x^{JT8D}_{w,out} = \dot{E}x^{JT8D}_{t,in} - \dot{E}x^{JT8D}_{u,out} - \dot{E}x^{JT8D}_{dest} \tag{14}$$

where $Ex_{w,out}$ is the waste exergy output of JT8D, $Ex_{t,in}$ is the chemical exergy of fuel in JT8D, $Ex_{u,out}$ is the useful exergy of JT8D and Ex_{dest} is the exergy destruction of JT8D.

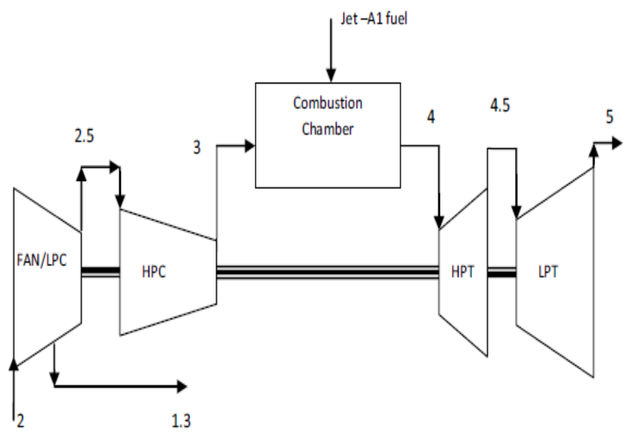

Figure 1. Schematic view of JT8D turbofan engine main components [7]

Exergy efficiency of JT8D is [11];

$$\eta^{JT8D}_{ex} = \frac{\dot{E}x^{JT8D}_{u,out}}{\dot{E}x^{JT8D}_{t,in}} \tag{15}$$

Waste exergy ratio is equal to the ratio of total waste exergy output to total inlet exergy [11];

$$r_{we} = \frac{\sum \dot{E}x_{w,out}}{\sum \dot{E}x_{in}} \tag{16}$$

Identification of T56 turboprop engine system and thermodynamic terms are listed below:

Energy balance equation in control volume and steady-state condition is [6];

$$\dot{Q} - \dot{W} + \sum_{in} \dot{E}_{in} - \sum_{out} \dot{E}_{out} = 0 \tag{17}$$

where Q is the net amount of energy transfer by heat, W is the net amount of energy transfer by work and E is the net amount of energy that in and out.

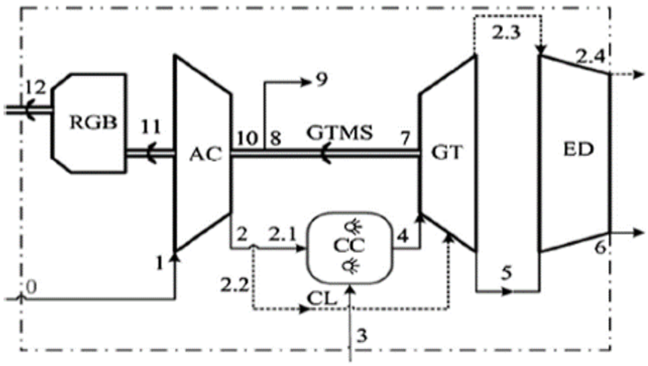

Figure 2. Schematic view of T56 turboprop engine [7]

For better explanation, some terms are identified on the basis of main components below:

For combustion chamber (CC) [11];

$$\dot{m}_{in}\cdot c_{P,a,in}T_{in} + \eta_{CC}\dot{m}_f\cdot LHV = \dot{m}_g c_{P,g}T_{out} \tag{18}$$

$$\dot{m}_{in} + \dot{m}_f = \dot{m}_g \tag{19}$$

where $c_{p,g}$, $\dot{m}_f$, $\dot{m}_g$, LHV and η_{CC} are specific heat capacity of combustion gases, mass flow of fuel, mass flow of combustion gases, the low heating value of the fuel and the combustion energy efficiency, respectively.

For exhaust dust [6];

$$\dot{Q}_{out} = \eta_{ED}\dot{Q}_{in} \tag{20}$$

For gas turbine mechanic shaft (GTMS) [6];

$$\dot{W}_{AC} + \dot{W}_{RGB,in} = (\eta_{GTMS}\dot{W}_{GT} - \dot{W}_{Acc}) \tag{21}$$

For reduction gearbox (RGB) [6];

$$\dot{W}_{Pr,TPE} = \eta_{RGB}\dot{W}_{RGB,in} \tag{22}$$

T56 turboprop engine was compared with PT6 turboprop engine, but the data is not given in this paper [7].

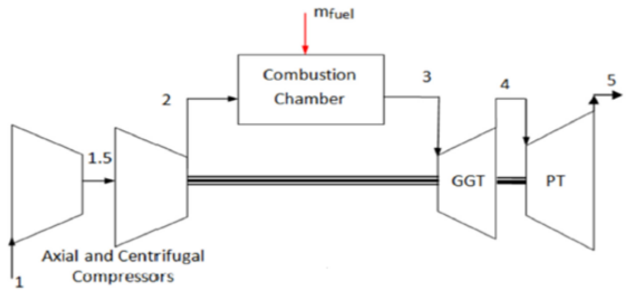

Figure 3. Schematic view of Makila1A1 turboshaft engine [7]

Enthalpy equation in steady state [6];

$$\nabla\cdot(\rho\delta h_i\mathbf{V}) = \nabla\cdot\left(\bar{\bar{\tau}}\mathbf{V}\right) - \nabla\cdot\mathbf{q} \tag{23}$$

Mass balance equation [2- 6];

$$\sum \dot{m}_i = \sum \dot{m}_o, \tag{24}$$

General energy balance is described as sum of income and outcome energy equivalencies [2-9];

$$\sum \dot{E}_i = \sum \dot{E}_o \tag{25}$$

General exergy balance [2- 9];

$$\eta_{ex} = \frac{\dot{E}x_i}{\dot{E}x_o} = 1 - \frac{\dot{E}x_{dest} + \dot{E}x_{loss}}{\dot{E}x_i} \tag{26}$$

where η_{ex} is equal to addition of exergy destruction and exergy loss divided by exergy inputs.

While the formulations above are applied for main engine components, some inferences are given below:

For centrifugal compressor (C_eC) [6];

$$\sum \dot{E}x_{in,CeC} - \sum \dot{E}x_{out,CeC} = \sum \dot{E}x_{dest,CeC} \tag{27}$$

$$\sum \dot{E}x_{in,CeC} - \sum \dot{E}x_{out,CeC} = \dot{W}_{CeC} + \dot{E}x_{1.5} - \dot{E}x_2 \tag{28}$$

Makila 1A1 turboshaft engine identification with scheme and both general and component based thermodynamic descriptions are listed below. The turboshaft could not be compared with other turboshaft engines due to inadequate data in the literature. It is compared with other general engine studies.

$$\dot{W}_{CeC} = \dot{m}_a(h_2 - h_{1.5}) \tag{29}$$

$$\eta_{ex,CeC} = \frac{\dot{E}x_2 - \dot{E}x_{1.5}}{\dot{W}_{CeC}} \tag{30}$$

For axial compressor (A_xC) [3];

$$\sum \dot{E}x_{in,AxC} - \sum \dot{E}x_{out,AxC} = \sum \dot{E}x_{dest,AxC} \tag{31}$$

$$\sum \dot{E}x_{in,AxC} - \sum \dot{E}x_{out,AxC} = \dot{W}_{AxC} + \dot{E}x_1 - \dot{E}x_{1.5} \tag{32}$$

$$\dot{W}_{AxC} = \dot{m}_a(h_{1.5} - h_1) \tag{33}$$

$$\eta_{ex,AxC} = \frac{\dot{E}x_{1.5} - \dot{E}x_1}{\dot{W}_{AxC}} \tag{34}$$

For combustion chamber (CC) [3];

$$\sum \dot{E}x_{in,CC} - \sum \dot{E}x_{out,CC} = \sum \dot{E}x_{dest,CC} \tag{35}$$

$$\sum \dot{E}x_{in,CC} - \sum \dot{E}x_{out,CC} = \dot{E}x_2 + \dot{E}x_{fuel} - \dot{E}x_3 \tag{36}$$

$$\eta_{ex,CC} = \frac{\dot{E}x_3}{\dot{E}x_2 + \dot{E}x_{fuel}} \tag{37}$$

For power turbine (PT) [3];

$$\sum \dot{E}x_{in,PT} - \sum \dot{E}x_{out,PT} = \sum \dot{E}x_{dest,PT} \tag{38}$$

$$\sum \dot{E}x_{in,PT} - \sum \dot{E}x_{out,PT} = \dot{E}x_4 - \left(\dot{W}_{PT} + \dot{E}x_5\right) \tag{39}$$

$$\eta_{ex,PT} = \frac{\dot{W}_{PT}}{\dot{E}x_4 - \dot{E}x_5} \tag{40}$$

For gas-generator turbine (GGT) [3];

$$\sum \dot{E}x_{in,GGT} - \sum \dot{E}x_{out,GGT} = \sum \dot{E}x_{dest,GGT} \tag{41}$$

$$\sum \dot{E}x_{in,GGT} - \sum \dot{E}x_{out,GGT} = \dot{E}x_3 - \left(\dot{W}_{GGT} + \dot{E}x_4\right) \tag{42}$$

$$\dot{W}_{GGT} = \eta_m \cdot \left(\dot{W}_{AxC} + \dot{W}_{CeC}\right) \tag{43}$$

$$\eta_{ex,GGT} = \frac{\dot{W}_{GGT}}{\dot{E}x_3 - \dot{E}x_4} \tag{44}$$

3. RESULTS

In this paper, some energetic and exergetic parameters of selected engines have been examined. Each of the engine parameters are compared with their counterparts at different conditions by using calculations and identifications listed above. While considering each parameter, calculations are also applied to make comparisons between AE3007H and JT8D turbofan engine, T56 and PT6 turboprop engine (not all of the studied data is shown in this paper). However; Makila1A1 comparisons could not be completed due to absence of parameters in literature.

Figure 4 demonstrates the exergy efficiencies of turbofan engines. As seen above; the highest efficiency at different conditions is seen in high power turbine (HPT), whereas the lowest efficiency is seen in both of the engines combustion chamber (CC).

On the other hand, exergy destructions in both of the turbofan engines are seen in combustion chamber (CC) respectively. On the contrary; the lowest exergy destruction is seen in high power turbine (HPT). Combustion reaction totally affects the exergy destruction due to chemical reactions.

Figure 5 (left) illustrates exergy efficiencies of studied turboprop engines. Like turbofans, the most efficient component is gas turbine; in contrast to the least efficient combustion chamber. Combustion reaction directly affects whole efficiencies, this means that more reaction means less efficiency. Another figure (right) describes exergy destructions of turboprop engines. As expected, highest destruction is seen in combustion chamber while gas turbine has the least.

In Figure 6; Makila1A1 turboshaft engine exergy efficiency values are shown for main components. Like others, the most efficient component is gas generator turbine (GGT), compared to the least efficient component the combustion chamber. On the contrary; destruction of exergy is observed for the turboshaft engine. The results are the same for other engines.

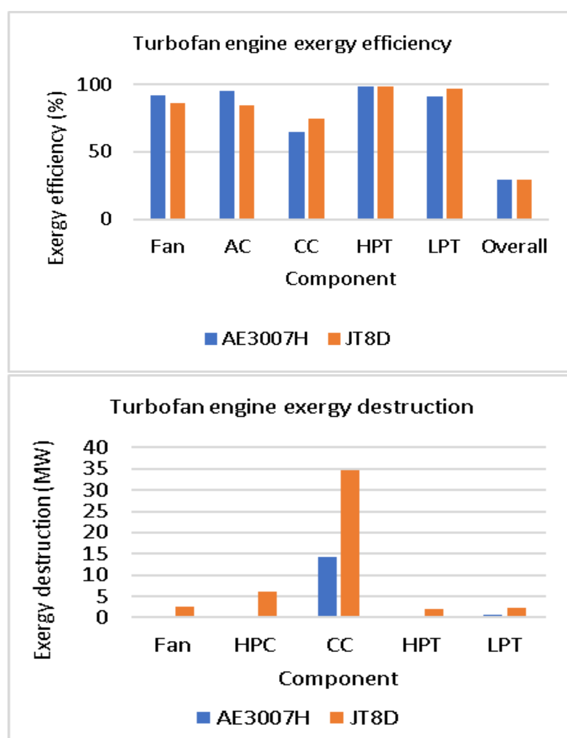

Figure 4. Exergy efficiency (upper) and exergy destruction (below) of turbofan engine

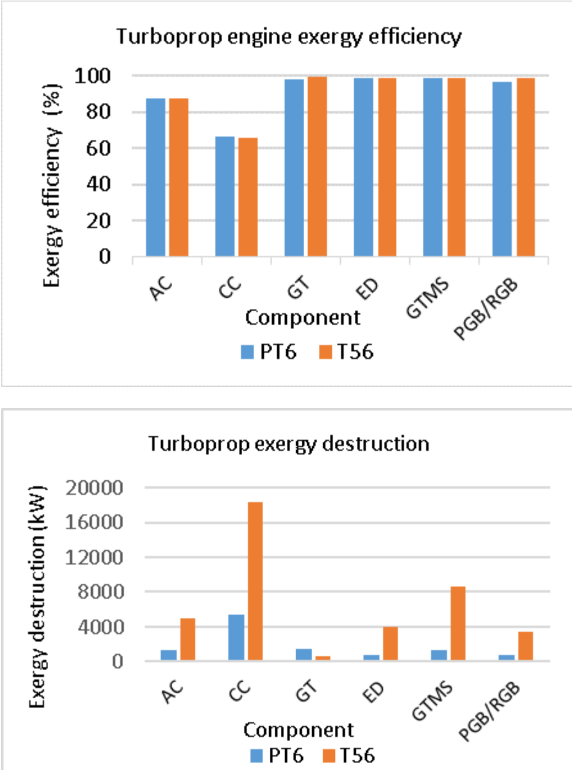

Figure 5. Exergy efficiency (upper) and exergy destruction (below) of turboprop engine

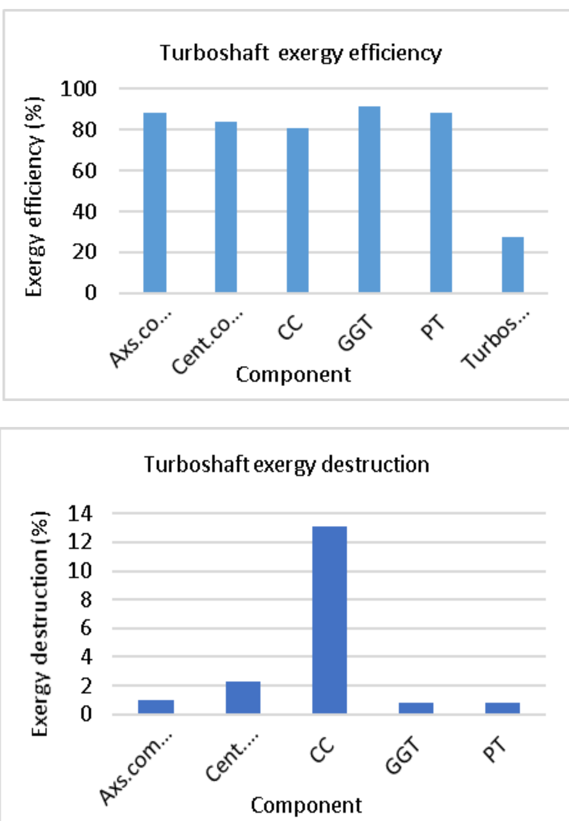

Figure 6. Exergy efficiency (upper) and exergy destruction (below) of turboshaft engine

4. DISCUSSION

During the study of analysed aircraft engines; some assumptions and simplifications are applied to make analyses shorter and finding results easier. These assumptions are given below:

- All of the studied engines are assumed as steady-state during operation time. Flow of air and other combustion gases in engines are assumed to behave ideally, and the combustion reaction is complete.
- Engine accessories are not included during these analyses. The potential and kinetic exergies are neglected, because their effect for total is nearly zero. The fuels in engines are assumed to burn ideally; their chemical formulas are taken as $C_{11}H_{21}$ for JetA1and $C_{12}H_{24}$ for JP-8. All of the components in engines are assumed adiabatic while heat loss is accepted as zero.
- Ambient temperature and pressure of JT8D are 288,15 K and 101,35 kPa same as AE3007H. For T56; these values are 298,15 K and 93,6 kPa, same as PT6. For Makila1A1, values are 288 K and 101,3 kPa, respectively.

When a comparison is made between all engines, the highest exergy destruction occurs in the combustion chamber. That result can be decreased via some design change; but never decreased to nearly zero. The reason for this is the irreversibility of combustion reaction. On contrary; exergy destruction is lower in fan, compressors and turbines. According to Ref (7), it is possible to proceed with alternative methods for these components.

Engine exergetic performance is also linked with environmental factors. For instance; exergy efficiency increases in higher altitudes, and decreases in lower altitudes. Therefore, the lowest exergy efficiency is observed in take-off, climb and landing phases of flight.

To increase shaft power in the engine; fuel flowrate should be raised. To increase fuel flowrate also increases shaft power, so exergy efficiency is observed in higher degrees.

Whether from common consideration or advanced exergetic analysis results, it is clearly realised that the combustion chamber, air compressor and power turbine are more dominant than other components. These are also identified as key components to achieve better R&D results among engine components that were investigated above. Also, sustainability and exergo-economic studies lead to better results in terms of efficiency.

5. CONCLUSION

In this paper; some parameters of selected engines (AE3007H, JT8D, T56, PT6, Makila1A1) at different conditions have been investigated. These parameters have been compared with each one and in general.

During the study, engines are operated in different environmental or working conditions and compared with each other, so that similarities and differences linked to the conditions can be better observed.

In summary, even if considered at different cases and conditions; all the energetic-exergetic balances and their effects on engines are in total agreement with the first and second law of thermodynamics. This can be understood from performances of engine components during operation.

Engine manufacturers and developers are still following new inventions to develop more advanced engine components, so that better efficiency can be achieved in future.

Environmental effects (pollution, adverse effects on nature or human etc.) must not be forgotten during all studies. Common aim for all studies must be “more efficient engines for environmental benefits”.

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Simulation of rice straw gasification in bubbling bed reactor using ASPEN PLUS

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Abstract: The global dependence on fossil fuels and the environmental effects of them are some of the factors that urge research on using biomass sources. Gasification is a process which converts carbonaceous materials into syngas. In this study, a bubbling bed gasification model is developed for the gasification of rice straw as a feedstock by using ASPEN PLUS. Thermodynamic equilibrium model which is based on the minimization of the Gibbs free energy of the system was used. The results of gasification in bubbling bed gasifier were verified by using data from literature. The gasifier temperature and steam flow rate are the most important parameters that influence the chemical composition of the syngas for the rice straw gasification in bubbling bed gasifier. Increasing steam-to-biomass ratio enhances H_2, CH_4 and CO production, while decreases CO_2. Furthermore, results showed that the developed bubbling bed gasifier model can be robust model, if gasifier temperature is selected within the 500–1000 °C temperature range.

Keywords: Rice Straw, Bubbling Bed Gasifier, Biomass Gasification, Aspen Plus, Simulation.

I. Introduction

Increasing global energy demand and environmental worries, researchers to shift fossil fuels with clean energy resources. In Europe, biomass is recently used as renewable energy sources for electricity generation, biofuels production for transport, useful heat generation especially [1]. Biomass as a renewable energy source, which includes variety of waste materials from plants or animals, reduces gas emissions. After biomass utilization process, CO_2 released to environment but biomass absorbs CO_2 from the environment during photosynthesis. Because of this cycle, biomass carbon dioxide becomes neutral. Biomass types have many differences according to their chemical and physical properties. Elemental composition, moisture content, ash and volatile matter content are the main properties of biomass [2]. Heating value is one of the most important parameter that effects the biomass usage. Lower heating value of biomass provides effective heat and mass transfer thus system is worked with more energy efficient and higher performance.

Gasification process has been identified as a promising method to convert biomass source into fuel gas due to its low cost and high fuel gas production efficiency [3,4]. Biomass gasification aims to convert solid biomass into a syngas which mainly consists of hydrogen (H_2), methane (CH_4), carbonmonoxide (CO), carbondioxide (CO_2), water (H_2O) and trace amount of higher hydrocarbons. Gasification process is consist of four parts, biomass drying, pyrolysis, gasification and combustion. Several chemical reactions take place under steam, oxygen and/or air atmosphere in the gasification process. Steam gasification increases the hydrogen yield of product gas and also provides higher standard synthesis gas [5]. The main products of gasification such as syngas, tar, char and their properties and amount depend on the operational conditions, gasification agent and elemental and physical properties of feedstock [6,7]. Depending on the process, produced gas can be used to create diesel or gasoline, methanol for the chemical industry, hydrogen fuel and fertilizers by processing ammonia [8].

Gasification is also preferred for the lower pollutant effects and more efficient heat and power generation [9,10]. On the other hand, gasification requires to develop modern gasifiers to prevent problems regarding biomass tar production, product gas impurities [11,12].

Gasifiers are the reactor type where gasification process occurs [13]. Gasifier types includes fluidized bed, fixed bed, and entrained flow are chosen with respect to biomass properties such as size, shape, ash content, amount, moisture content and operation terms [14]. Fluidized bed gasifiers have fluidization principle that bed material and fuel act like fluid [15]. Silica is the mostly used inert bed material for fluidized bed gasifiers, although other materials such as sand, dolomite, glass beads and olivine show catalytic features and reduce tar problems. Fluidized bed reactors divide into two categories according to their technics of fluidization; bubbling fluidized and circulating fluidized [14]. The main aim of the fluidized bed gasifier is to improve heat and mass transfer among the fuel particles and gasification agent. The bubbling bed gasifier has many advantages in terms of high carbon conversion efficiency, homogenous temperature distribution and flexibility regarding feedstock type and size. Bubbling bed gasifiers has complicated process so are influenced from many properties such as steam/fuel ratio, reaction temperature and equivalent ratio. All of these properties effect directly chemical composition of the syngas in bubbling bed gasifier [16,17].

Modeling based methods provide alternative and economical ways to the designing and optimization of complicated systems such as gasification [18]. Aspen Plus is an useful program to optimize system parameters. It is used to develop model which is more cost effective than experimental studies. Many researchers are used Aspen Plus for modelling of gasification process. Han et al. [19] developed an air-gasification model using Aspen Plus and investigated the effect of main parameters in biomass gasification on the quality of produced gas based on minimizing Gibbs free energy. Rupesh et al. [20] found that H_2 reached the maximum value (H_2 volume percentage of 31.17%) at steam/biomass ratio of 1.0, ER of 0.25 and gasification temperature of 900 K using Aspen Plus. Nikoo and Mahinpey [21] carried out simulation of gasification based on bed hydrodynamics and reaction kinetics using Aspen Plus. Lan et al. [22] developed an integrated biomass gasification via Aspen Plus and showed the effect of the main parameters for power generation.

The main purpose of this study is to provide a general model for the type of bubbling bed gasifier by using Aspen Plus program. The proposed model was validated with the experimental data sets obtained from the literature. To investigate the impact of operation parameters including gasification temperature and steam flow rate on the composition, heating value and exergy of syngas from bubbling bed rice straw gasifier, the sensitivity analysis was applied.

II. Materials and Methods

In this part, biomass sample properties, block diagram of bubbling bed gasifier, process assumptions and definition of the blocks used in the Aspen Plus software is reviewed.

A. Materials

Biomass characteristics are the main factors affecting the heating value, composition and exergy of syngas from the developed Aspen model, therefore, they are detailed in this study. The rice straw used in this study was supplied by the local suppliers from north of Turkey. Rice straw is an organic waste material which is result of rice production. Rice residues causes environmental pollution especially in places where production take place on large scale.

TABLE I. Proximate and ultimate analysis of rice straw

Proximate Analysis (wt%)	Volatile Matter	68.52
	Ash	14.34
	Moisture	2.55
	Fixed Carbon	14.59
Ultimate Analysis (wt%)	Sulfur	2.06
	Oxygen	53.66
	Nitrogen	0.79
	Hydrogen	5.13
	Carbon	38.36

Ultimate and proximate analysis results were conducted according to ASTM Standard D5373-2 and ASTM Standard D5142-04, respectively. The results are identified in Table 1. Mass percentage of the oxygen content was determined by the difference in a dry ash free basis content, using Eq. 1.

$$O(\%) = 100 - (N + C + H + S) \quad (1)$$

B. Model Description

Bubbling fluidized bed gasifier model has been studied according to principles of chemical, energy, and mass balance by using Aspen Plus simulation. Gasification model flowsheet is built by using different blocks in the Aspen Plus software. Stream informations and physical property method is inserted to system to conduct simulation. The developed model in this study is based on the principle of minimization of Gibbs free energy to reach equilibrium. Syngas production process under steam atmosphere includes several process which are low temperature pyrolysis, high temperature pyrolysis and gasification, respectively. Pyrolysis is a thermochemical decomposition, which can be applied to any organic (carbon-based) product. Biomass was defined as a non-conventional component for Aspen plus BIOMASS stream, the low temperature pyrolysis converts the biomass into its conventional components. High temperature pyrolysis is the first step for the conversion of rice straw to syngas. After pyrolysis steps, gasification has been simulated at between 500-1000°C to determine the optimum gasification temperature. In the simulation of gasification process, the following assumptions were considered:

- Model operates in steady-state conditions
- It is an isothermal process
- There is no pressure decrease in the gasification parts
- All gases behave ideally
- Ash is inert and is not involved in reactions which is occurred in gasification process.
- Bio-char conversion is 100%

There is not a particular reactor or block to define the gasifier, in Aspen Plus simulation. Combination of different block was used to represent the gasification process. The reactor is divided into three sections as Decomp, Gasif1, Gasif2 as shown in Fig. 1.

TABLE II. OPERATION BLOCKS IN ASPEN PLUS MODEL

ID	***Block Type***	***Description***
DECOMP	RYIELD	Biomass converts into conventional components
GASIF1, GASIF2	RGIBBS	Simulates the gasification reactions by using Gibbs free energy minimization
SPLITTER	FSPLIT	Dispenses steam into Gibbs reactors
SEP1, SEP2	SEP	SEP1 block performs the separation of certain amounts of CH_4 and CO_2. SEP2 block separates water, H_2S and ash from producer gas.

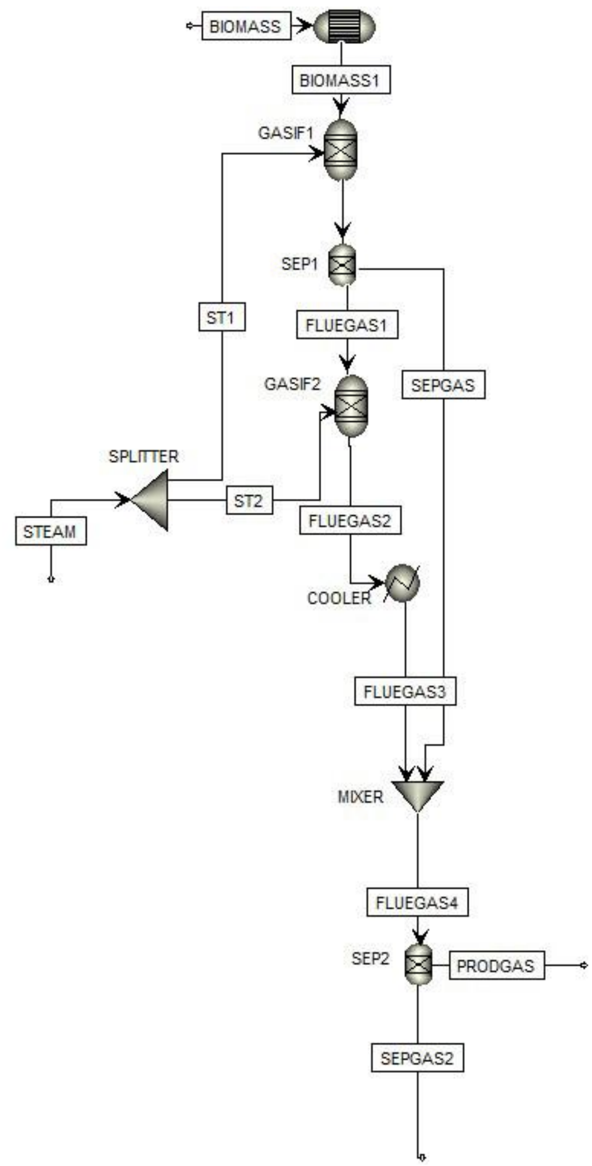

Fig. 1. Flow Sheet of Rice Straw Gasification.

Biomass is fed into to Decomp reactor which is identified RYIELD in Aspen Plus. In Decomp reactor, form of rice straw was changed from nonconventional to conventional components which are oxygen, hydrogen, nitrogen, carbon, ash and sulfur according to the its proximate and ultimate analysis.

Steam is divided into two streams via FSplit block which was named as Splitter to create steam atmosphere in the Gasif1 and Gasif2. RGIBBS block was used to simulate the pyrolysis part where is occurred in Gasif1. Sep1 block was placed to perform the separation of certain amounts of CH_4 and CO_2 before gasification step. Gasification reactions is occurred in the Gasif2 block which is represented also RGIBBS reactor. Flugas2 which is produced by gasification process is sent to Cooler block to decrease the product gas temperature. Flugas3 is mixed with Sepgas which is coming from Sep1 block via Mixer. Block Sep2 simulates the removal of water, H_2S and ash. Syngas is obtained water and ash free form, it is generally consist of methane, hydrogen, carbonmonoxide and carbondioxide.

Biomass type, operational conditions and gasification agent can affect the gasification reactions. The moisture from rice straw affects the equilibrium of chemical reaction and involves in gasification reactions such as steam methane reforming reaction, water gas shift reaction, water gas reaction. Medium molecules decompose into the smaller molecules such as carbon monoxide, methane, carbon dioxide and hydrogen (Eq. 9,10). If the residence time during the reaction is not long enough to decomposed for medium molecules, they will formed as tars and oils and go to oxidation zone. Pyrolysis region products reacts with the gasfying agent for production of smaller molecules. In the reduction region, water gas reaction (Eq. 7), water gas shift reaction (Eq. 4), methanation reaction (Eq. 2) and steam methane reforming Eq. (8) Boudouard reaction (Eq. 5) occur because of inadequate oxygen in the high temperature region. The reactions in bubbling fluidized bed gasifier are represented in Table 2.

TABLE III. GASIFICATION REACTIONS

$C + 2H_2 = CH_4$ (hydrogasification reaction)	(**2**)
$C + 1/2O_2 = CO$ (partial oxidation reaction)	(**3**)
$CO + H_2O = CO_2 + H_2$ (water gas shift reaction)	(**4**)
$C + CO_2 = 2CO$ (Boudouard reaction)	(**5**)
$H_2 + S \rightarrow H_2S$	(**6**)
$C + H_2O = CO + H_2$ (water gas reaction)	(**7**)
$CH_4 + H_2O = CO + 3H_2$ (steam reforming reaction)	(**8**)
$C + O_2 = CO_2$ (complete oxidation reaction)	(**9**)
$H_2 + 0.5O_2 = H_2O$ (hydrogen oxidation)	(**10**)

III. RESULTS AND DISCUSSIONS

A. Model Validation Results

Experimental data sets from the literature have been used to validate and create the appropriate model for bubbling fluidized bed gasifier. Two different data sets from literature [23, 24] have been chosen for the validation of developed model. The simulation was carried out with the same operational conditions from literature as seen on Table 3. In the first one, wood pellet was chosen as feedstock, gasification temperature is 800°C and air is gasifying agent , air and biomass flow rate is represent in Table 3. Second experimental data from literature is also shown in Table 3, tire sample is feedstock, gasifier temperature is 770°C and steam is used as gasfying agent.

TABLE IV. EXPERIMENTAL CONDITIONS AND VALIDATION RESULTS OF AIR AGENT GASIFICATION [23] AND STEAM AGENT GASIFICATION [24]

	1	
Wood Pellet	Biomass(kg/h)	34
Gasifier - 800°C	Air(Nm^3/h)	37
Gas Composition	1	Model(%)
H_2	14.5	15.67
CO_2	16	16.44
CO	13.8	13.91
CH_4	4	9.09
	2	
Tire Sample	Biomass(kg/h)	0.876
Gasifier – 770°C	Steam(kg/h)	0.331
Gas Composition	1	Model(%)
H_2	48.81	47.87
CO_2	3.30	3.56
CO	3.89	3.2
CH_4	26.37	14.3

As it can be seen in Table 3, H_2, CO, CO_2 compositions are very similar in the experimental and the developed model. However, CH_4 composition from the air gasification data from literature, it is quite different compared to other gas compositions because the Aspen Plus model works basis of thermodynamic equilibrium so fuel residence time in the gasifier would be different in the model and experimental study. From the validation results of the developed model, we can obtain that in spite of there are some differences in validation results, these deviations are not that important, the simulation model give a quite good idea of the product gas composition. It is the main goal of this model.

B. Model Results

After model validation, a series of bubbling bed simulation were conducted in order to observe the effects of steam flowrate and temperature on the syngas composition and its LHV and exergy value. Sensitivity analysis was used to investigate effect of temperature and steam flow rate on the syngas composition, LHV of syngas and exergy value of syngas.

1) Effect of Gasification Temperature

a) Syngas Composition: The plot of selected syngas composition (CO_2, CH_4, H_2 and CO) on a dry basis as a function of temperature have been shown in Fig. 2. The model performed sensitivity analysis for the bubbling fluidized bed gasifier for the temperature between 500–1000 °C.

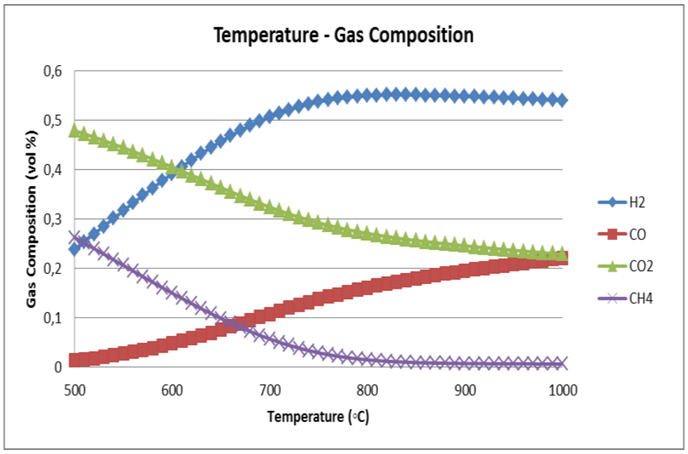

Fig. 2. Effect of gasification temperature on syngas composition.

Endothermic char gasification and steam reforming reactions play a significant role for the increase in H_2 and CO molar fractions. At lower gasification temperatures, which is below the 700 °C, CO and H_2 molar fraction increased with the temperature change. However, at relatively high temperatures, the endothermic reactions are reinforced through the temperature change, which proves the feasibility of Le-Chatelier's principle [25]. With respect to Boudouard reaction, while the gasifier temperature increasing, mole fraction of CO_2 decreases and CO increases. H_2 mole fraction changes between %23,8 and %55.1, it reaches to maximum value at 840°C. Gas composition change is negligible between the gasification temperature 850-1000 C. An increment in gasification temperature could be rise the operational charge. CO is converted to H_2 via water gas shift reactions and a faster growth rate is observed in H_2 than CO. CH_4 concentration decreased, while H_2 and CO concentration increased because of the methanation reaction. CO_2 molar fraction change showed a similar tendency with the change of CH_4 molar fraction. Former studies in the literature shows the similar results for gasification process in bubbling fludizied bed gasifier.For example, Skoulou et al.[26] found that, the mole fractions of H_2 and CO increased and mole fractions of CO_2 and CH4 decreased with increasing temperature. Begum et al.[27] also studied effect of gasification temperature on syngas composition and found same results for the municipal solid waste (MSW) gasification process.

b) Lower Heating Value (LHV): LHV of syngas is a physical property which is a very important parameter for the energy evaluation of gasification process. Lower Heating Value (LHV) of syngas depends on the combustible properties of components. Temperature effects the mass basis syngas LHV positively, Fig. 3 shows the behavior of syngas LHV versus temperature.

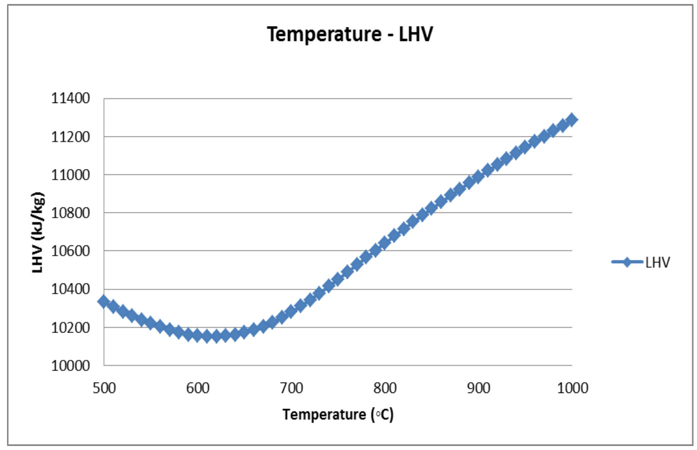

Fig. 3. Effect of gasification temperature to syngas LHV.

Among the all combustible component in syngas, CH_4 is the more effective component than H_2 and CO for the syngas LHV. LHV decreases with temperature increases between the temperature 500-620°C because of the decreasing of CH_4 mole fraction. Then H_2 and CO mole fractions, which favor LHV, rise up fairly with increasing of temperature results the enhance in Fig. 3.

c) Exergy: Exergy is the helpful tool for performance analysis of systems. The increase in temperature promote the exergy value of the syngas composition because of the enhancement of chemical exergy value through H_2 and CO production. Moreover, physical exergy with the temperature increase also assist the exergy value of syngas composition. On the other hand, excessive temperature change influences the gasification reactions results decreasing exergy value. According to the sensitivity analysis in this study, maximum exergy has been obtained at the 820°C as seen on Fig. 4.

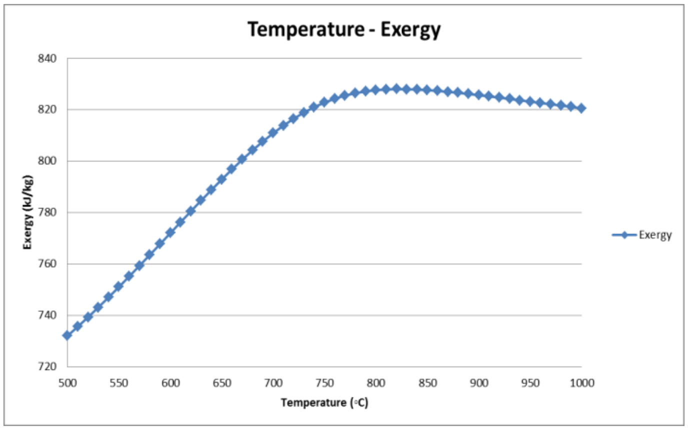

Fig. 4. Effect of gasification temperature to syngas exergy.

2) *Effect of Steam Flow Rate*

a) Syngas Composition: To observe the effect of steam flow rate on syngas composition, a sensitivity analysis was conducted at steam flow rates of 7 and 60 kg/h. Fig. 5 shows the variation of syngas composition (CO_2, CO and H_2) at different steam flow rates. The steam flow rate remarkably influenced the composition of syngas generation during steam gasification, and increasing of steam flow rate shifts directions of reactions (steam-methane reforming and water-gas shift) to Hydrogen production. H_2 mole fraction increased in the syngas.

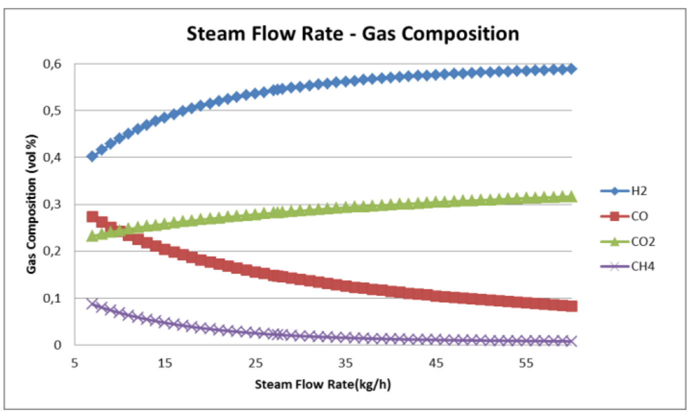

Fig. 5. Effect of steam flow rate to gas composition.

Complete combustion reaction occurs more than partial combustion reaction with increasing amount of gasifying agent. Thus, higher steam flow rate decreases the mole fraction of CO from %27 to %8 and increases the mole fraction of CO_2 from %23 to %31 in the syngas. CH_4 mole fraction decreased from %8 to %0.08 because of steam-methane reforming reaction shifts to product side with increasing steam flow rate. Therefore, methane mole fraction decreases and H_2 mole fraction increases via steam methane reforming reaction.

b) Lower Heating Value: LHV is expressed the energy contents. Components in the syngas have different energy content. The selectivity of the gasification reactions varies with steam flow rate, thus affecting the composition and LHV of syngas. Fig. 6 presents the LVH at different steam flow rate.

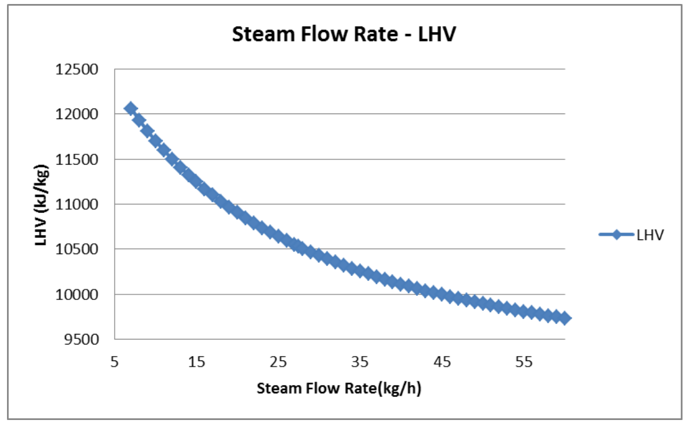

Fig. 6. Effect of steam flow rate to syngas LHV.

In the Fig. 6, it can be seen that LHV decreases with the increase of steam flow rate. The increment in steam flow rate complete oxidations includes CO_2 formation. As a result of complete oxidation reaction, CO_2 amount increase and CO amount decreased and combustible component amounts decreased significantly. CH_4 is the important combustible component and influeces the lower heating value of syngas. As seen on Fig. 5 CH_4 composition in syngas and LHV value of syngas shows decreasing trend with temperature increases. For this reason, LHV of syngas has a decreasing tendency between 12000 and 9500 kJ/kg.

c) Exergy: Exergy analysis is used to performance evaluation of the gasification process. Fig. 7 shows the exergy value from rice straw gasification under steam atmosphere at different steam flow rate.

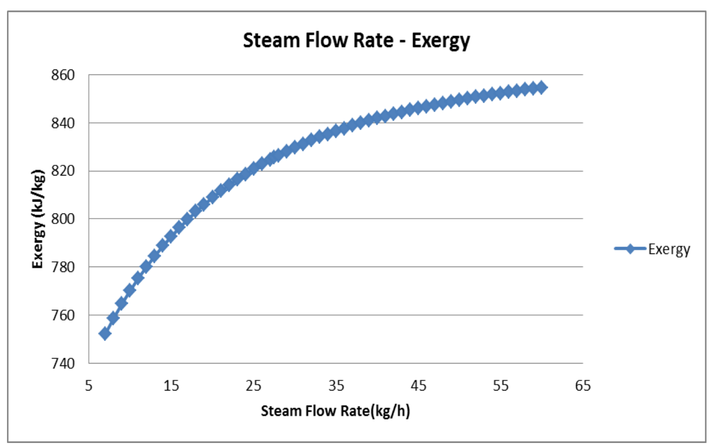

Fig. 7. Effect of steam flow rate to syngas exergy.

When the steam flow rate was increased from 7 to 60 kg/h as seen on Fig. 7, the exergy value increased. The increase in steam flow rate favoring hydrogen production via gasification reactions includes hydrocarbon cracking reactions, water gas reaction (Eq.7), methane steam reforming reaction (Eq.8), water gas shift reaction (Eq.4), and steam gasification of condensable volatiles under steam atmosphere. Therefore, the results show that the exergy value from steam gasification of rice straw is mainly determined by the chemical exergy of biomass because of the hydrogen production.

IV. Conclusion

With respect to the objectives of this study, we conclude that:

• Bubbling fluidized bed gasifier model successfully validated with two experimental data sets.

• System was designed to utilize the biomass as feedstock that produced synthesis gas.

• We examined the effect of different working parameters for bubbling fluidized bed gasifier using sensitivity analysis.

• Temperature and steam flow rate showed considerable effects on the composition of syngas.

• LHV and exergy value of syngas is strongly influenced by the operation temperature.

• H_2 and CO content increased slightly with the increase of the temperature, to be more specific the content of H_2 increased by about 33% from 500°C to 820°C, while the content of CO increased by about 15% from 500°C to 820°C.

• LHV decreased while temperature increase between 500°C to 620°C; increasing of temperature from 620 to 1000°C, LHV was shown an increasing trend from 10154 to 11285 kJ/kg.

• Increment in temperature, exergy value increased and reached the maximum value at the 820°C.

• Effect of steam flow rate is observed on the syngas lower heating and exergy value.

• With the addition of steam, the content of H_2 increased significantly, from 40% to 58%. Molar fraction of CO decreased and molar fraction of CO_2 increased between 27% to 8% and 23% to 31%, respectively.

• LHV of syngas changed between 12000 and 9500 kJ/kg while steam flow rate increased from 7 to 60 kJ/kg.

• Increasing of steam flow rate, the exergy value of syngas increased from 752 to 854 kJ/kg. Exergy value and molar fraction of H_2 of produced gas show same trend with temperature change.

• LHV and exergy value of syngas have been effected by increment of H_2 and CO production.

• For future study, the developed bubbling bed gasifier model will be integrated with a gas turbine, steam turbine or high temperature fuel cell stack.

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Parametric Comparison of Four Different Missile System

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Abstract: In the design of a missile, the rocket engine, aerodynamics, structural warhead, fuse, launcher and control unit are important with the guidance system. Four different missiles named as Atgm_1, Low Drag_8, Patriot_TR, and New Missile are designed. The structure and working principle of the missiles are analized. The designed missiles were simulated at a platform with shooter and target values determined by the Rocket Simulator Program. Speed, distance, altitude, mach number and maneuverability number which are important criteria during the cruise, test flight or when the missiles take action to hit the target were evaluated by test flights in the simulation.

Keywords: Defence Technologies, Defence Industry, Missile Design, Test Flight

1. INTRODUCTION

Missiles and rockets have been very active and effective military weapons due to the ongoing cold wars, technological competitions and military strategies of the countries. So, they have an important place in terms of defense industry. Missiles are military vehicles that investigate the target in the direction of the target point. Missiles are mechanisms that can be adapted for different functions and tasks, can be controlled and have the ability to observe. These highly equipped mechanisms with high communication systems, electronic sensors and smart software can also hit their targets at very close range if decision making systems are added to the design. Missiles can be classified according to their dropout conditions, whether they are long or short range, control system or monitoring systems and guidance methods [1, 2].

The current development technologies of the defense industry sector accelerate the reliability and accuracy of the missile mechanism. Missiles with guided system are attracted more attention because of their success in military operations. Moving or directing of a physical object from one place to another can be achieved by many methods. If an object that changes its position is expected to reach its certain target or to aim an active object, a guidance mechanism must be designed for this object. Some reasons like unexpected displacement of the target, deviation from the target due to wrong aim, changing of the trajectory due to weather conditions causes the failure performance of missiles. If a warhead is used in larger areas, but size of missile also get increased. Another method is to use the closed loop system in guided systems. Thus, the rate of deviation from the target decreases and the probability of destruction increases in one shot [3-6].

Missile is the mechanism driven by the thrust created by burning of a flammable object. Unlike rockets that are directed to a specific target by unguided, missiles can be moved in the target direction using the guidance method [7]. A missile includes some units as below;

- The seeker to find the target,
- Fins that allow the missile to focus on the target and an engine system that performs its movement,
- Guidance and control units that resolve all errors detected in the missile and decide the orientation.

Moreover, the missile systems consist of a heat with heat (IR) guidance or radar-guided seeker, sensors, tracking and control antennas, optical systems for infrared waves, electronic and flight tracking systems, warhead and propulsion systems [8].

An aerodynamic model of a guided missile includes all control and thrust variables covering kinematic values, geometric characteristics and aerodynamic interactions. Also force components in a set of axes specified with respect to the direction of flight as bearing force, drag force, lateral force and torque components as pitching torque, yaw torque are mentioned.

Aerodynamic designs and analysis of four different missiles named as Atgm_1, Low Drag_8, Patriot_TR, and New Missile are given in this paper. Test flights of the missiles are simulated in the Rocket Simulator Design. In next section, the structure and working principle of the missiles are introduced. In the third part, the design of the missiles is presented for rocket engine and guided algorithms. The Analysis of the aerodynamic configuration values and static parameters are evaluated by Rocket Simulator Program. The results and conclusion in the simulation of flights are introduced in the last section.

2. THE WORKING PRINCIPLE OF THE MISSILE

The working of a missile is based on the response principle. Missiles which use liquid fuel, liquid oxygen or nitric acid operate at high speed in the space and atmosphere. These fuels are sprayed inside the combustion chamber and a reaction is composed by ignition. Oxygen causing the combustion of the fuel in the missiles is saved inside the missile. Thus, the missiles also can be operated in space [9].

While the missile follows a predefined trajectory after the firing phase, the seeker tries to find the target. Following the locking system, the seeker transfers the target information to the command computer. So, the guidance computer performs the necessary operations and sends the necessary commands to autopilot. The autopilot sends control surface commands to the propulsion control system using information transmitted from navigation and sensors. The propulsion control system performs these commands within its dynamics and changes the direction of the forces falling on the missile. Thus, the missile is located in a new position.

Guidance unit in missiles includes trajectory control system and position control system. The function of the trajectory control system sends necessary commands for tracking the trajectory to the position control system. The function of the position control system is to control the wobble, pitching and turning angles. As a result of the calculations by these systems, the control surface commands are created to stay on the appropriate orbit and transmitted to the actuators in the control section [10].

The trajectory of the guided missiles from the firing point to the target may be in different ways according to the control and guidance methods. The most widely used orbital systems are; Straight Line Orbit, Navigation Orbit, Line of Sight Orbit, Proportional Navigation Orbit, Ballistic or Free Fall Orbit.

3. THE DESIGN ANALYSIS OF THE MISSILES

Four types of guided missiles are designed in this work, and these missiles are; Atgm_1, Low Drag_8, Patriot_TR, and New Missile. These missiles were designed by Rocket Simulator program. Rocket engine, aerodynamic design, warhead, missile, guidance system, launcher, control unit of missiles are analyzed comparatively for all design process of the missiles.

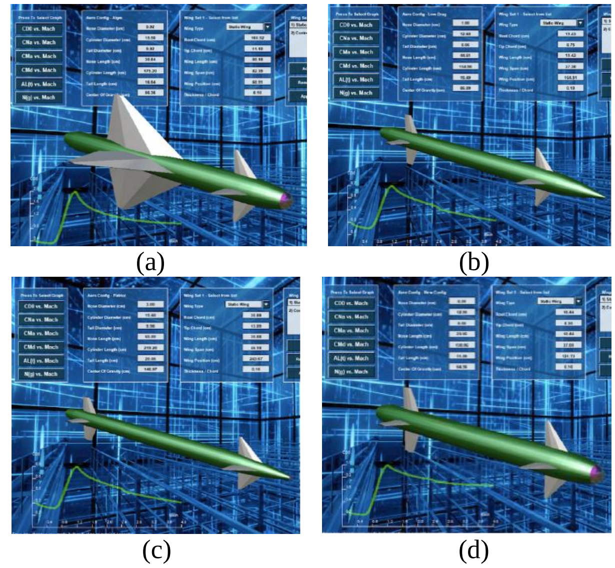

Figure 1. Aerodynamic design of the missiles a) Atgm_1 , b) Low Drag_8, c) Patriot_TR, d) New Missile

3.1. Design of Rocket Engines

Firstly, static tests are performed of the missiles calculated with some specific values of rocket engines. So, the main parameters of the thrust, chamber pressure, exit pressure, mass of propellant and impulse coefficient of nozzle are calculated mathematically. In the table 1, the static test parameter measurements of the rocket engines for all missiles are shown.

Table 1. Static Test Parameter Values of Missile Rocket Engines

Static Test Parameters of Rocket Motors	Atgm_1	LowDrag_8	Patriot_TR	NewMissile
Thrust	312.7 kgf	228.9 kgf	378 kgf	168.1kgf
Chamber Pressure	29.8 atm	31.3 atm	35.5 atm	35.5 atm
Exit Pressure	1.2 atm	0.7 atm	1.4 atm	0.7 atm
Mass of Propellant	0	0	0	0
Impulse Coefficient of Nozzle	1.46	1.46	1.48	1.48
Time	17.4 sec	13.3 sec	15.8 sec	9 sec

Thrust which is required for the missiles to move platform is realized by the propulsion systems. Thrust is generated through some application of Newton's third law of motion. For every action there is an equal and opposite reaction. Propulsion systems are the mechanisms that enable the generation of a force in the opposite direction as a result of the acceleration of the high pressure gas generated by the reaction of the fuel with the oxidizer in the combustion chamber. Hence, the missile travels to the target by this thrust force of the propulsion system. The rocket engine of the missiles performs sufficient thrust to exceed of both the weight and dragging of the missile. The missile can rise through the highest altitude, when the fuel runs out. Accordingly, static firing test is performed in order to calculate the performance of the rocket engine. In this test, the engine is ignited by connecting to a special platform and parameters of the engine such as thrust, temperature and pressure are calculated based on time.

Particularly, the total impact of the engine is calculated using thrust-time data and this measurement value is compared with theoretical calculations to verify the rocket engine. The thrust of the rocket engine is used to accelerate the missile and fight the missile's friction force in the air. A well-designed engine maintains the high speed obtained from the bust stage and enables the missile to reach long distances and to use the maneuverability ideally.

Patriot_TR has the highest thrust value according to data shown in the table 1. Atgm_1 has the longest burning time of rocket engine.

Rocket engines operating according to the action-reaction principle use the impulse that occurs during the extraction of high-energy combustion products. The biggest segment of the impulse is formed by the acceleration and removal of gases with high temperature and pressure inside the combustion chamber with the help of a small hole nozzle [10]. Under normal conditions, the combustion chambers in the rocket engine are between 10 and 200 atm and operated at an extremely high pressure value. According to the data in the table 1, two missiles with the highest combustion chamber pressure are Patriot_TR and New Missile. Then, Low Drag_8 and Atgm_1 follow them. The exit pressure of the rocket engine is one of the most important factors that affect the performance of the engine. Patriot_TR has the highest exit pressure in the table After, Atgm_1 has the second highest exit pressure [11, 12].

The propellant powder can be defined as the chemical or explosive substance that provides energy for dispatching the missile. The mass of all propellant in the table is 0 kilograms.

The thrust coefficient of nozzle which is the ratio of the thrust force to the combustion chamber presuure and the cross-sectional area is a dimensionless parameter that characterizes the amount of exhaust gas from the nozzle. Patriot_TR and New Missile have the highest thrust coefficients of nozzle in the table.

3.2. Analysis of Aerodynamic Configuration Values

Basically, Aerodinamic coefficients as drag coefficient, normal force coefficient, control torque coefficient, pitching torque coefficient, attack of angle coefficient, and maneuverability coefficient are calculated according to the mach number. The aerodynamic coefficient values of the missiles are compared in the Table 2 below.

Table 2. Aerodynamic Coefficient Values of Missiles

Aerodynamic Coefficient Values	Atgm_1	Low Drag_8	Patriot_ TR	New Missile
Drag Coefficient	1	0.3	0.3	0.7
Normal Force Coeffient	26	8.9	9	8
Pitching Torque Coefficient	36.6	6	3.3	4.3
Control Torque Coefficient	6.4	6	13.5	5.7
Angle of Attack Coefficient	1.6	12	28.6	17.7
Manueverability Coefficient	22.3	40	40	40

Drag coefficient in the air can be defined as a number used to model the complex dependencies of the drag force according to the shape slope and a number of flow conditions. The rocket gains speed as it descends, so the drag increases. The rocket is arrived at the destination when the drag is equal to the weight but in the opposite direction. For a normal missile, the drag coefficient has an average value of 0.75. As shown in the Table 2, Atgm_1 has the highest drag coefficient value. After that New Missile has the second one for the drag coefficient value.

The aerodynamic system in a missile has two important force components which are drag force and normal force [13]. According to the data in the table, Atgm_1 has the highest normal force coefficient and it is about three times greater than other three missiles. After, Low Drag_8 and Patriot_TR have the second highest value and they are equal. New Missile missile has the lowest normal force coefficient.

Pitching torque coefficient which is defined as the torque around the lateral force axis is another significant criteria of aerodynamic configurations [14]. The pitching torque occurs in the interval between the center of mass and the center of pressure in the missile by the wind force. In other words, the pitching torque is the movement of the missile’s nose in the up and down directions during the orbital movement [15]. In the table 2, Atgm_1 has the highest pitching torque coefficient and this missile is significantly higher than the other three missiles.

Control torque coefficient refers to the angle of deflection of the missile from the control. This aerodynamic coefficient depends on wing angles, mach number, angle of attack, and angle of slip. In the Table 2, Patriot_TR has the highest control moment coefficient. After, Atgm_1, Low Drag_8 and New Missile follow it. Moreover, control torque coefficients of these three missiles are close to each other.

The angle of attack is defined as the angle realized by the plane in the missile movement axis set and the missile speed vector. Also, in the missile axis set, the angle between the components on the x-axis and z-axis of the velocity vector is expressed as the angle of attack**.** Patriot_TR has the highest angle of attack coefficient. Atgm_1 missile has the lowest angle of attack coefficient value in the data.

Maneuverability is an important criteria for missiles to reach the desired target correctly and to hit the systems in motion. It is achieved by controlling the wings and small ailerons in the tail and wing sections of the missile. Furthermore, the guidance systems determine the missile's maneuverability. The maneuverability of missiles varies according to the target type and the purpose of the operation. Low Drag_8, Patriot_TR and New Missile have the highest maneuverability coefficients. Atgm_1 has the lowest value.

3.3. Design and Analysis of Guidance Systems

Basically, fin lock time, detection range, heatseeker diameter, flight path following guidance system and terminal guidance were given in the Table 3.

In the guidance systems of missiles, the aileron lock mechanism is adjusted to increase the performance of the missile by minimizing the drag [16]. The fins are important for the missile to stay in the motion stability. The pressure center should be located behind the center of gravity for a stable flight. The fins do not need to be active, because stability can be achieved with fixed wings that are simple and costly compared with wings in active control surface in the unguided rockets. Locking of the fins occurs at the bust stage of the system. The missile travels in a ballistic orbit and locks the fins and also the guidance system cannot be worked in the bust stage. So, it is allowed the missile to accelerate its maneuver without losing stability and speed. The fin lock time is designed to adjust the maneuvering speed of the missiles in the simulation program. In the Table 3, the fin lock times of all missiles are the same.

Table 3. Guidance System Parameters of Missiles

Guidance System Parameters	Atgm_1	LowDrag_8	Patriot_TR	NewMissile
Fin Lock Time	1 sec	1 sec	1 sec	1 sec
Detection Range	1000 m	1000 m	1850 m	1000 m
Seeker Diameter	15 cm	10 cm	14 cm	10 cm
Midcourse Guidance	Remote Command-Intercept Line	Remote Command-Intercept Line	Remote Command-Line of Sight	Remote Command-Line of Sight
Terminal Guidance	Self Homing-Proportional	Self Homing-Proportional	Self Homing-Dog Chase	Self Homing-Dog Chase

The size of the seeker determines the target's detection distance at the terminal stage of the system. It is expected to catch the target by following different energy types such as radio wave, laser reflection, infrared, visible light or sound. According to the data in the Table 3, Patriot_TR has the longest detection range. The detection ranges of all other missiles are the same.

The seeker is a system that allows missiles to track and follow until that they hit the target. Atgm_1 has the largest seeker diameter. New Missile and Low Drag_8 missiles have shorter seeker diameter than other two missies and they have same seeker diameter values.

The flight path following guidance system is involved in the process from the end of the missile launching phase to the beginning of the terminal guidance system phase. One of the main purpose of the guidance system is to direct the missile to the most appropriate position. So, attacking to the target becomes more effective in the terminal phase [17, 18].

In the guidance system phase, the missile is normally too far to detect the target itself. Therefore, it uses a commanded guidance system from the launcher or control unit. There are generally two types of methods which are the line of sight method and the intersection point method. The line of sight method is used in many anti-tank missiles. In the intersection point method, the launcher part of the missile calculates a predicted or planned intersection point and directs the missile towards that point. The line of sight guidance system is a line between the place in which the missile was launched and the target. A different number of lines of vision are composed of different times along the path of the target. Shown in the Table 3, Atgm_1 and Low Drag_8 missiles use the intersection point guidance system in the flight path following guidance phase. On the other hand, Patriot_TR and New Missile missiles use the line-of-sight guidance system.

In the terminal guidance system phase, the target detection distance of the missile is determined. This system, which is the last stage of the guidance system, is the most critical phase. The guidance system in the terminal phase must be highly accurate and react quickly to signals. At this stage, the missile's maneuverability is crucial to catch and hit the target. For this reason, the performance capabilities of the missile should be compatible with the terminal guidance system. The greater the target acceleration, the more critical the terminal guidance system is.

The change of the missile velocity vector angle is proportional to the change of the line of sight in the proportional navigation guidance system. One of its important advantages is that it does not need much information about the characteristics of the target. The movement of the target relative to its follower constitutes the basis of proportional navigational guidance. Moreover, proportional navigational guidance is used to verify missile route in high speed missiles. The missile aims to reset the angle of the sight line to the target. The simplicity of this system is the most marked feature. Atgm_1 and Low Drag_8 missiles use proportional navigation guidance system in the terminal phase. However, Patriot_TR and New Missile missiles use the tracking guidance system at this stage.

3.4. Comparative Analysis of Static Tests

After the design analyzes for all missiles, speed, range, mach, and maneuver parameters were evaluated in the static test. It is analyzed that how fast the missile was, how fast it would gain speed after the engine was fired, how long it would fly, and how far it would reach in this test.

Table 4. Static Test Parameters of Missiles.

Static Test Parameters	Atgm_1	Low Drag_8	Patriot_TR	New Missile
Speed	150 m/s	145 m/s	160 m/s	170 m/s
Range	16000 m	19961 m	24815 m	10710 m
Mach	0.4 M	0.5 M	0.6 M	0.5 M
Maneuver	7 g	7.5 g	7.3 g	4.4 g

At the static test simulation with the rocket simulator program, the missiles are assumed to fly as straight flight at the sea level. The engine's thrust is used to accelerate the missile and fight the missile's friction force in the air. A well-designed engine maintains the high speed obtained from the bust stage enabling the missile to reach long distances and making the most of maneuverability. At the end of the static test, the engine and aerodynamic values of the missile can be improved. As shown in the Table 3, New Missile has the highest speed. Later, Patriot_TR, Atgm_1 and Low Drag_8 follow it.

The range of the missile is as important as its speed in the operations. Because, the range is determined by the location of the target and it can be changed during the mission. Also, the missile must reach long ranges after being thrown from the launcher in order to hit the target. In the Table 3, Patriot_TR is the missile that reaches the longest range. After, Low Drag_8, Atgm_1 and New Missile missiles follow it.

When the missile reaches a certain speed, the air cannot catch the missile's speed. When the missile reaches the speed of sound, it cannot find the air to pass through. At this point, shock waves are formed. Variable air pressure in the shock wave causes modification in the forces acting on the missile. In this case, the current passing through the wings changes, the friction and pressure on the tail increase. Shock waves have a great effect on an object that reaches the speed of sound. To measure this effect, missile speed and sound speed are compared. This ratio is called Mach number.

For example; if a missile flies at twice the speed of sound, than mach number is 2. If the sound speed is flying at half speed, than mach number is 0,5. According to the data in the table, the missile with the highest Mach number is Patriot_TR missile. Later, New Missile and Low Drag_8 missiles follow it, and they have same mach number. Atgm_1 has the minimum mach number.

The most important feature of the missile expected during the mission is that it hits the target with high maneuverability in a short time. Therefore, the maneuverability of the missile is very important. Maneuvering performance also affects the command signals, the performance of high acceleration and attack angles in the missile**.** The maneuver values of Atgm_1, Low Drag_8 and Patriot_TR missiles are close to each other. However, the missile with the highest maneuverability is the Low Drag_8. Later, Patriot_TR and Atgm_1 missiles follow it. New Missile has the lowest maneuver value.

4. RESULTS AND CONCLUSION

In the design of a missile, the rocket engine, aerodynamics, structural warhead, fuse, launcher and control unit are also important with the guidance system. The designed missiles were simulated at a platform with shooter and target values determined by the Rocket Simulator Program. Speed, distance, altitude, mach number and maneuverability number which are important criteria during the cruise, test flight or when the missiles take action to hit the target were evaluated by test flights in the simulation. The results are given at the Table 5 for the test flights.

The missiles require high speed in order to be effective against high-speed ones, to move faster than them, to make sudden maneuvers, to resist high accelerations and to eliminate any deception by other aircraft. According to the data in the table 5, the missile with the highest speed for the test flight is the Patriot_TR missile.

Tablo 5. The simulation results of the test flights

Simulation Values	Atgm_1	Low Drag	Patriot_TR	New Missile
Speed	350.3 m/s	560.9 m/s	689.8 m/s	386.3 m/s
Range	1990 m	1875.9 m	1967.6 m	1650.7 m
Altitude	667.5 m	650.5 m	871.3 m	627.1 m
Mach	1 M	1.7 M	2 M	1.1 M
Manuaver	5 g	0.5 g	5.4 g	0.3 g

The speed of the missile is important as well as the distance it travels. The distance is varied depending on the location of the target. Also, the missile had to reach long distances after throwing off the the launcher to hit the target. According to the data in the table above, the missile that reached the longest distance in the simulation test flight is the Atgm_1 missile.

Altitude is the vertical distance of any object or point calculated on the basis of average sea level. In other words, this parameter can be defined as the total rise and advance of the missile received during the flight. The altitude parameter varies according to the intended use of the missiles. Generally, it appears as low altitude, medium altitude and high altitude. High-altitude missiles are used for long-range targets. However, at higher altitudes the air density decreases, so the aerodynamic and engine performance of the missile changes. Medium altitude is generally used in field or point defense to eliminate the target at medium altitude. Low altitude is preferred against threats located close to the ground. According to the data in the table above, the missile that reached the longest altitude in the simulation test flight is the Patriot_TR missile.

The most important feature of the missile expected during its duty is to hit the target in a short time with high maneuverability at a specified distance. The maneuver performance of the missiles following the targets should be extremely effective. It also affects the command signals in the missile, the performance of high acceleration and angles of attack. The missile which has the best manueverability is the Patriot_TR.

According to the five criteria given in the table 5, the missile with the lowest performance in the simulation test flight is the New Missile missile. Low Drag_8 missile ranks second in speed and mach number tests. Atgm_1 missile is the second according to altitude and manuevaribility tests. In the distance test, Atgm_1 missile as a guided tank destroyer missile takes first place, Also it is used in medium missile and long range to destroy armored vehicles. The Low Drag_8 missile is designed as a low air friction missile. According to the five criteria in the table above, the lowest performance of the missiles is deternmined as the New Missile.

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High-Tech. Spectrum of Nano-Architecture

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Abstract: Engineering, Architecture and Medicine are the concepts that exist since the human being has been created in the world, arise regularly in response to human needs health, practice and living. Nevertheless, do we ever consider before the correlation between nano-engineering, nano-architecture and nano-medicine in terms of the nano-structured solutions that scientists discover worldwide in an interdisciplinary platform, getting advance rapidly. Until 2000s, the most inventive revolution was industrial revolution that hit the headlines during 18., 19. century, based on steel and its innovations. However, today the science world considers and discuss for nanotech as a contemporary intelligence that will be expected to be the world leader forever. So, what are the dreams and what are the limitations for this new nano-world, how efficient are the results, how much repetitive, what is the criteria for the success and what must be the standards? The aim of this research welcomes all the scientists to a new dimension of the nanotech world to discuss for all the affects, critics and drawbacks of nanoscience. What are our concerns, how safe it is, what can be the further risks that we have to face in terms of the health concerns on human and environmental concerns on nature? The size nano has a big question that disorient our minds which is hardly possible to guess all the effects without experiencing the drawbacks. Therefore, the question is; how it could be possible to get precautions against toxicity and how to make a balance to adopt to a new high tech world of nano-architecture? On the other hand, what makes nano-tech so innovative and what creates the magic? How quantum theory and nano-particle kinetics concepts manage to amaze nano-scientists with its innovations and extraordinary outcomes? Is it possible to create shortcut solutions between the results that has been achieved in nano-medicine to nano-architecture? How the theory and application procedure of nano-tech can be parallel to multiple solution concepts? How sustainable are these solutions? With all the great intelligence of nano-world, how it is possible to enhance the quality standards of high tech buildings and constructions, how these new findings affect the mechanical strength, structural configuration and construction technology. Moreover, high tech building technology standard by using nano – innovation technology goes towards to a new dimension that have been called “smart building technology and smart cities”. In this concept, “zero energy buildings” theory is a main research area for all the construction scientists coming with a big question to discuss “what cause zero energy? How this could be possible?” Meantime, the construction technology is going towards a century that multifunctional creations and designs has been awarded and worth to discuss for. The recent instance and the most intelligent creation that has been emerged is ‘SHED NY Art Center” completed on 5 April 2019, by Diller Scofidio + Renfro Architecture Design Office. Exclusively, all these innovations on the idea of construction and functionality challenge brings the responsibility to find new solutions for the emerging energy and efficiency needs for these high tech creations. All in all, “Smart Building Technologies” and “Solar Panel Concentrator Systems” for this type functional creations are new criterias that need to be discussed further to find the source of the energy for the routine management of this type buildings. So, how efficiency standards could be modified related to advancement of the construction technology and how the new sources of the energy could be provided? During this research, the answers of all these questions will be criticized with all aspects. An innovative algorithm will be created about the way how to integrate the needs, with solutions, norms and regulations of nanotechnology. Evaluation of efficiency (EE) and success parameters will be examined that will result to understand the limits and the advantages of nano- treatments, with the drawbacks and risks as well. The idea of this research has application to patent for Politecnico di Milano POLIMI IRIS: 05.1. Brevetto & Patent Application: 2018. Nanotechnology In Architectural Restoration: Science & Innovation: Hybrid Nano - Composite Design for Consolidation of the Porous Structures: Limestone & Bone “Transport Phenomena”, ID: hdl:11311/1065405

Keywords: Architectural Engineering, Nano- Architecture, Kinetic Architecture, Nano-Composite, Nanoparticle

1. INTRODUCTION

Especially, in the last decade, in lots of research studies discussed about the innovation that has been carried out with the basics of nano-tech. [1][2] This raising interest has getting an accelerating attention among science world, starting since 2004, even to get ahead to double the number of the publications in comparison with silica, seeming to be the leader until that moment. [3] Afterwards, roles have been changed, nowadays the question is if silicon valley has been ready to abdicate its throne to nanoscience valley, and moreover if this magic of nanotech is certainly real to follow; how much safe and how much repetitive it is. What could be the health risks on human/environment and how it is possible to get the necessary precautions against to toxicity problems of nano- sized particles. To be in the safe part, for this concept, it is necessary to understand what the nano-size means, nano-size is an incredible littleness that creates the magic by using the "quantum confinement effects" [4], 1nm is 1.0*E-9m. This unusual particle size comes with some disadvantages in terms of the inhalation problems in terms of health and safety in laboratory conditions, because the masks that has been used for standard chemical works generally have the adequate protection against powder/dust, and with some extra additive parts they can be useful for chemical vapor protection. However, nano-sized chemicals, with a possible negative impact of passing through the inconvenient mask filters, reaching the lungs and considering the potential toxicity risks, especially with the respiratory toxicity that has been shown the effect on mice, arise from SWCNT carbon nanotubes to cause lung cancer. [5]

On the other hand, another risk factor is spreading these nano chemicals to living atmosphere from their application zones. Little info has been known for long term effects of nanoparticles, so there are increasing concern among science world if the risk of release could be possible from the building materials and could cause harmful impact not only for human health but also for environment. [6] In contrast, there is a so well-known speech that chemistry is not innocent, as a reminder from organic chemistry laboratory studies in undergraduate years of chemical engineering and chemistry departments. All type of chemical compounds have some health risks and there are lots of precautions that laboratory researchers need to take into account. To be honest, with the nano-sized criteria of nanoparticles, the respiratory risks of toxicity are further than the standard sized usual chemicals, but to be in a meaningful consideration, this little nano-sized effect have also the positive potential impact that create the magic of nanoscience with its accelerated limits of penetration depth and adsorption criteria. So, even also having the risks of toxicity, nanotechnology has worth to take necessary precautions, with enhanced high-equipment laboratory conditions and to keep to continue searching on it.

Another discussion point for nanotech isstability criteria, that also has been found resolved, and advised to go further in University of Edinburgh researches. [7] When it comes to stability of the nano-composites, colloid stability and thermodynamic stability is a constant discussion point, needs to be go further. [7], [8]. Colloid stability in nano-particles is a crucial factor that can affect the efficiency of the results, by storage and preparation conditions of nanoparticles, needs to be considered first, before-application procedure, the reactivity performance of the nanostructured particles could able to differ, under the effects of the particle's aim to create agglomeration.

Sonication parameter is an efficient way to provide the right colloidal stability and to create effective application in this sense. [9] A study that has been carried out in 2018, at Harvard University Radcliffe Institute for Advanced Study, has proven, only 6 of 53 cases of the research works could be reproducible and safe with the constant results. [10] This crucial information has been accepted as a crisis on science world and created a question mark in minds, how sufficient and to what extent it is safe the results of the experimental analysis could be, while the research has got the proof that only 11% of the outcomes would be repetitive in historical perspective depending on science, technology and medicine. So, the new question is, how the standards of techno-world could be created the norms, in order to be more repetitive in terms of the conclusions and to what extend it is possible to be in the safe zone and to avoid the disrupting factors that can even create possible problems for the reliability of the outcomes.

2. BACKGROUND

2.1. Factors of Affecting the Efficiency of the Outcomes

In the research that has been carried out in the University of Edinburgh, HAP particles that has planned to get applied on archeological human bone structures, has been experienced to get analyzed in laboratory by researchers themselves. As the result the HAP had been obtained between the range of 20-600 nm particle size in formation even also their chemical composition are the same, surely. This problem has been named "agglomeration" which is known a major problem in terms of nanoparticles. [7] Nano-particles have the negative potency to aim to create agglomerates, and this issue directly influence their potential of reactivity, viscosity, penetration capability and efficiency [11]. When nano-sized particles create agglomerates, their size range differs, even also to cause undesirable size-range spectrum. Moreover, these phenomena directly have influence on the transport mechanism of the particles into deeper zones of the structures they are applied.

Regarding the problem of whitening and deposition for $Ca(OH)_2$ nanoparticles, lots of studies that has been carried out in literature, focus into what could be done to enhance the quality of the efficiency outcomes of nano-treatment therapy for limestone based structures, regarding especially for the conservation of the "CH" cultural heritage buildings. $Ca(OH)_2$ nanoparticles, so called nanolimes, has been widely used lots of researches [2] [12] [13] in heritage preservation literature, but their efficiency potential has not still been adequate as the result of their accumulation, whitening and deposition problems. In some studies, modifying the solvent composition between ethanol to water in different ratios has been discussed [14], also the application procedure has been taken into account by differing the absorption technique from capillary action to nebulization [15], then experiences have been go deep into directly modifying the solvent composition with different kinds of alcohols, having different dynamic viscosity properties ranging from 1:2 ratio, from ethanol to butanol, respectively, in order to evaluate the drying rate mechanism, and kinetic stability in response. [16] Drying rate for nano- particles, has been also discussed for 3 different kinds of lithotypes (lime mortar, limestone and sandstone) in DRYMASS Research Project that has been carried out in Lisbon National Laboratory for Civil Engineering, with the importance on the influence on back migration and losing from surface for nano-particles. [17] In terms of nanolimes, because of the reason of solvent evaporation from the surface, some of the $Ca(OH)_2$ nano-particles evenly losing from the surface, if adequate carbonation process not be successful, so called, named "back migration effect". Back migrated particles also have the un-desirable potential to create accumulation on outer surface of the building material that can evenly cause the aesthetics problems in terms of CH buildings, especially. In this case, whitening problem on surface has to be discussed. So, selecting the correct solvent with suitable drying rate, moreover avoiding the back-migration with after-treatment applications could be good solutions for better penetration and enhancing the quality of the nano-treatment. [11].

2.2. Stability Concerns: Colloid Stability/ Thermodynamic Stability/ Kinetic Stability

"Colloid stability" is a concern that can evenly make difference on particle based systems in dispersion and colloidal phases. In a research study that has been carried out under the support of European Commission, "NANOCATHEDRAL" project, suspension stability in different mediums from water to alcohol has been discussed. Reminding the concerns that has been experienced in Edinburgh University studies on "archeological bone, limestone and autoclaved concrete" substrates which has been described above [7], in NANOCATHEDRAL research work, three different lithotypes (marble, sandstone and limestone) has been evaluated on 6 real site monuments, under the effects of different weather conditions, located in different geographical regions from Pisa/Italy to Oslo/Norway, with various temperature and relative humidity %RH factors of environmental conditions.

In consolidation case, "TEOS tetra ethyl orto-silicate "in combination with nano-SiO_2 and nano-ZrO_2 has been searched, and in protection case nano-TiO_2 photocatalytic activity has been discussed. By using "on site monitoring systems" on real site monuments, evaluation process has been performed efficiently for the success of nano-treatment in composite forms. [18] After the research and final critics of Edinburgh University study, Nano-Cathedral Project again focused on the importance of the "colloid and suspension stability" on the serious effect on success potential of the outcomes.

"Thermodynamic stability" is another concern in terms of stability theory that temperature differences can evenly affect the behaviors of nano-composites such as polymer-clay combinations. In a research study that has been performed in Texas State University in USA, "thermodynamic stability" has been accepted as the essential case in order to the nano- composites to be useful in their ongoing analysis. [8] "Kinetic stability", discussed above in DRYMASS research project, is an essential factor that can even affect the efficiency for nanoparticle based treatments, just a similar case with the importance of the stability factor in the pharmaceuticals industry in medicine; "chemical stability, physical stability, microbiological stability and toxicology stability". [19]

2.3. Emulsions and Art Works

In Piero Baglioni works [2] [20], managed to get successful results in terms of preservation of art works for heritage preservation, "microemulsions theory" has been discussed. P. Baglioni also introduced the "Ferroni Method" and the importance of the dispersions of nanoparticles to the scienceworld. For enhanced control of consolidation works Baglioni advised to use alcohol based dispersions on wall paintings and stone consolidation works, also using Japanese paper sheets and adding some $Ba(OH)_2$ barium hydroxide has been offered. Baglioni has also focused on elimination of acidity for paper, canvas and wood, related to heritage art works. [21]

2.4. Smart Building Technology for Nano-Architecture

Innovation of nano-architecture concept in the most efficient way to understand the importance of the material science and the differentiated spectrum range, possible to force the limits of design and typology in terms of architectural engineering. (Fig. 1,2) Innovation make sense, moreover, in basic term, to make creations using desired properties are meaningful. To create something new or to get advanced a design means to use differentiated and more powerful tools / techniques, by the challenge of bounding the limits and capabilities.

Figure 1. Design Concept Image 1 for "Shed NY Art Center – Smart Buildings Technology", by Diller Scofidio + Renfro Architecture Design Office [22]

Figure 2. Design Concept Image 2, Steel Case Structure in front, for "Shed NY Art Center – Smart Buildings Technology", by Diller Scofidio + Renfro Architecture Design Office [22]

Nano-Architecture is in the basic definition, to use advanced techniques and innovative materials for architectural design and to create something new, more desirable, more attractive and useful as well (Fig. 3,4,5). The aim will be the functionality and aesthetics aspects of design in the same platform, as the luxury and the comfort in terms of building physics, basics of architectural design. Nanotech, high tech needs to be get on well with the desired capabilities and high performance for the building physics. [1] (Fig. 6a,6b)

Figure 3. Design Concept Image 3 for "Shed NY Art Center – Smart Buildings Technology", "Creation of Functionality", by Diller Scofidio + Renfro Architecture Design Office [22]

"Shed NY Art Center" has been recently advanced the rules of the construction and has proved innovative designers how a building could be in the top point of the functionality, efficiency and kinetic architecture, with all the outcomes it welcomes to science-world. Shed, by using the rail system technology, have movable case structure with steel construction system in its background, and glass facade covers for the enhanced trans lucidity.

Figure 4. Design Concept Image 4 for "Shed NY Art Center – Smart Buildings Technology", Steel Case Structure in front, by Diller Scofidio + Renfro Architecture Design Office [22]

Shed NY has been completed on 5 April 2019 by Diller Scofidio+Renfro Architecture Office, with the proof of the advanced level functionality on building science and the creation of design. The construction of Shed, also opens to all building construction scientists a new research area that how to make feasibility assessment for building integration systems in terms of their energy needs and efficiency. For this concept, smart building technology seems to be so much connected with the solar panel technology that is also one of the new challenges, getting advanced enhancement in Sweden, recently, April 2019 [23].

Figure 5. Design Concept Image 5 for "Shed NY Art Center – Smart Buildings Technology", Detail of the Extraordinary Rail System, by Diller Scofidio + Renfro Architecture Design [22]

Figure 6a. High Tech Innovation –using nanomaterials as proven case of sustainability in design process, ECOWEEK, Thessaloniki, Greece [1]

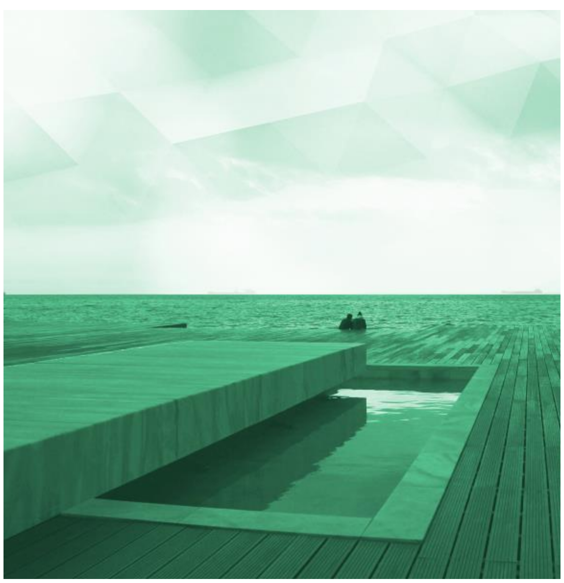

Figure 6b. Innovation in Architectural Design in terms of high tech material technology, using nanomaterials on the effect of the meaning of aesthetic aspects, Mediterranean - Greece, DESIGN ECOWEEK [1]

On the other hand, efficiency desirable process design needs much more technical details (Fig. 7) in terms of differentiated energy modules. In this sense, the aim could be functionality awarded design, taking in the energy in the first steps of efficiency, using the advanced solar panel technology for the facade of the high-tech buildings can able to create and advance the efficiency levels of well-integrated buildings. It is proven that "Smart Buildings Technology" concept have integrated potential to combine architectural design functionality and engineering technical know-how connections with the "Solar Panel Concentrators" systems.

With a related connection of "Building Integrated Photovoltaic Modules" system, that has been also discussed in the recent studies of the research group "ESRI Electron Science Research Institute" in February 2019 [24], "transparent and luminescent concentrators, photovoltaic building integration systems and solar windows" could be a potential source of the needs for the high-tech innovative functional building technologies.

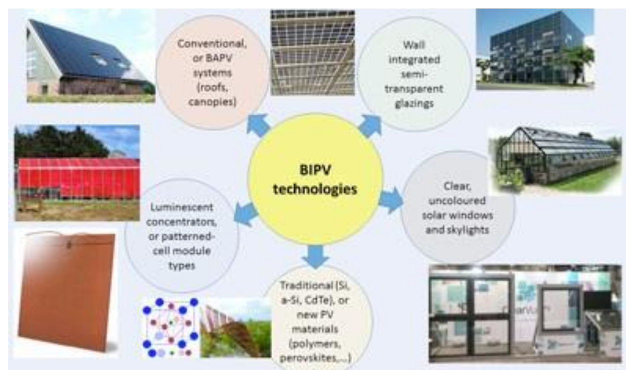

Figure 7. Building Integration Photovoltaic Technologies, recent research by ESRI Electron Science Research Institute, in February 2019. [24]

In an exclusive open-minded consideration with the connection point between the "solar panel concentrators" sytems, "building integration photovoltaics" and "advanced hybrid nano-composite technology" systems, science world could have the potential to discuss on the availability and performance criteria of the nano-particles technology and how to adopt the desired nano-particles and advanced nano-coatings systems for the service of the enhanced quality for the smart building technology integrated systems.

For the proven cases of the high-resistant and advanced level durability performance properties of the nanomaterials, nano- tech based construction ideas are open discussion points for all the researchers of construction science that needs to go further for the potential performance enhancements and to understand the limits of the interconnection points between these unique disciplines of building strategies, that can even create the innovation in a high-tech level of construction world for nano- architecture systems.

3. METHODOLOGY

3.1. Range Spectrum Between Nano to Micro and Different Orientation

Unique case studies of innovations could be the milestone in terms of finding creative solutions in order to overcome the described problems of nanotechnology. To use nano to micro particles together to form more rigid structures and to avoid the back-migration method is the most powerful technique, has been proved. [11], [25]. To go further with this idea, a research study has been awarded, which has been carried out in Ball State University in USA, by creating formulations “inconstantly located fibers into concrete” ranging from nano to micro scale in size-length, and in combination with carbon, steel and polymers, for the objective to enhance the mechanical strength of concrete performance. [26]

3.2. Creating Hybrid Nano-Composite Designs

3.2.1. Hybrid Nano-Composites in Architecture

A research study that has been carried out in Berkeley National Laboratories that the secret of the Roman Mortar has the clue of having hybrid composite design structure in itself, by combining the calcium-alumina-silica-hydrates (CASH) together. [27] Discovery coming from Berkeley Laboratories accepted as an “inherited intelligence”, through the first usage of hybrids and composites in architectural construction, with the proven cases of the secret of Roman Mortar comes from its hybrid designed morphological structures inside. Recently, another proven research has been obtained in European Commission NANOCATHEDRAL research project, that has been carried out to understand the effects of NPs nanoparticles into consolidation and protection cases. The combinations of TEOS (tetra ethyl silicates) in combination with NPs nano-particles has been discussed in NANOCATHEDRAL. Nano-silica and nano-zirconium has been preferred as the consolidant agent for expecting results to get efficiency on different types lithotypes. Aging factors has been already discussed by using artificial ageing procedures on lab tests. [28], [29], [30]. Photocatalytic activity based on TiO_2 titanium dioxide nanoparticles also has been evaluated. [31]

3.2.2. Hybrid Nano-Composites in Medicine

A research study that has been carried out at University of Orleans in France, has introduced science world with a discovery that there is a structural and meaningful connection between bone and limestone in terms of their chemical composition (that based on calcium) and morphological structure properties, proven with 2D sections and 3D high resolution tomography images, in terms of porosity criteria, that brings the transport phenomena similarities in these two porous media. [32] This porous media idea brightens our minds to go through to find integrated treatment capabilities between nano-medicine and nano-architecture, in sense. When it comes to making a correlation between nano- architecture and nano-medicine, on a similar way with nano- architecture and nano-composite technology; nano-medicine therapy, based on the essentials of architectural bone tissue scaffolding techniques, creating tissue formation in biomedical tissue engineering applications [33] [34]. Using the combinations of NPs such as: SiO_2, CaO, P_2O_5 and Na_2O, in order to form the bioactive glass scaffolds, a model of creating nano-hybrid forms in biomedical applications. In nano- medicine and tissue engineering concept, bone regeneration therapy, creating bone tissue engineering scaffolds based on combinations of different NPs, in creative, systematic diagrams, algorithm schemes, is a model of finding ways of load bearing defects against osteoporosis [35] and even also in dental applications.

3.2.3. Hybrid Nano-Composites in Aerospace Industries

Surface Coating functional coating systems against ice formation for aircraft wings has been an essential issue for safe flights. Regarding this problem, a European Commission Horizon Project PHOBIC2ICE has been studied for optimizing the right nano-hybrid designs for functional surface coatings regarding the aviation technologies. AIRBUS is the partner of this research group and LARFIS Polytecnique Montréal Canada LARFIS Laboratories has been used for the experimental analysis, silica coatings and their potency on hindering the ice formation on aircraft systems has been examined in detail. [36]

3.3. Standardization and Evaluating the Efficiency (EE)

Nano cathedral EU Project publications underline that there must be some certain rules regarding to nano-treatment applications such as; aesthetic compatibility, preventing the toxicity of nanomaterials, finding solutions for possible health concerns: regarding the respiratory problems for humans and avoiding the spreading possibility of the NPs to the environment. Also, safety of the results and to what extent the similar outcomes could be provided is an issue needs to be taken into account.

In the literature, evaluation criteria of the results with the preferred non-destructive methods, sensing technology tools of detection procedure, by using monitoring systems for onsite monitoring applications [6], and evaluation of the mechanical durability, compressive strength or flexural strength for laboratory test has been performed on samples. [11], [25]. IR- Photography, UV-Photography, 3-D Structured Light Scanning, and Color Photography has been used on site for the efficiency criteria. [37], [38] In order to evaluate surface morphology, SEM Scanning Electron microscopy, to evaluate interfacial structure TEM transmission electron microscopy and to evaluate phase microstructure XRD X-Ray Powder Diffraction has been used for outcomes of the nano-treatments. [39]

3-point bending test is a destructive testing method, to evaluate the evaluation of the efficiency, in terms of mechanical strength and withstanding time before cracking point of the sample (Fig. 9,10,11). With the data of withstanding time, it could be useful to go further for this data for the building durability cases against earthquake deteriorations. [25] On the other hand, in terms of the importance of the on-site monitoring applications on historical monuments, Chinese researchers have created a sensor that has highly sensitive performance for on-site monitoring applications. [26]

Figure 8. Destructive evaluation test, 3 Point bending test, to evaluate mechanical strength enhancement, [25]

4. CONCLUSION

Stability theory, and colloid stability is the main criteria in terms of the efficiency results in nanoparticle based technologies, having a direct influence on accumulation and deposition problems. Harvard University research by Nicole Nelson, Radcliffe Institute, has been proven unique case that only 11% of the experimental analysis research studies in terms of science, technology and medicine, has been likely to repetitive response and outputs [10]. In a meaningful consideration, these coincidental outcomes of the researches, in their backgrounds, must have negative points that can cause the un-desirable factors of the reliability of the responses and the results. For NPs nano-particles based treatments, considering the importance of the viscosity, penetration depth, surface adhesion and adsorption criteria [11], colloid stability affect the efficiency parameter of the results and reliability in nano-science. Sonication and mixing in high velocity mechanical stirring techniques (such as between the range of 400-600 rpm with a mechanical stirrer) are some of the solutions that researchers are trying to make the nano-dispersions stable before the application on substrate surface [25]. But, on the other hand, some solutions applicable on pilot size applications, could be carried out in laboratory analysis, possibly so difficult or in some cases, completely impossible with the inadequate technical conditions in the worksite area, such as the difficulty of finding a complexed sonicator before an application on site. In a meaningful sense, some practical solution techniques, even be possible in laboratory testing analysis, could be difficult on real site practice, in a more optimistic way, needs high cost, high experience, and well-talented workers to get well educated about the application procedure of nano-particles, to have precautions for back migration and agglomeration , but somehow the construction cost will force the limits, so on real site practice, process needs to well- analyzed and well-formulated before to start the process. Efficiency and the costs needs to be considered at the first stage.

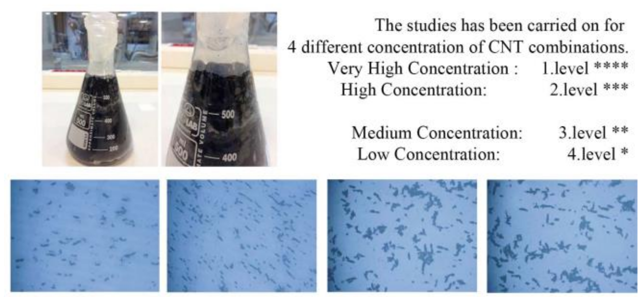

Figure 9. Effect of colloidal stability on CNT dispersions before application to samples of building material, searching the effect of Carbon nanotubes on mechanical strength of construction materials, [25]

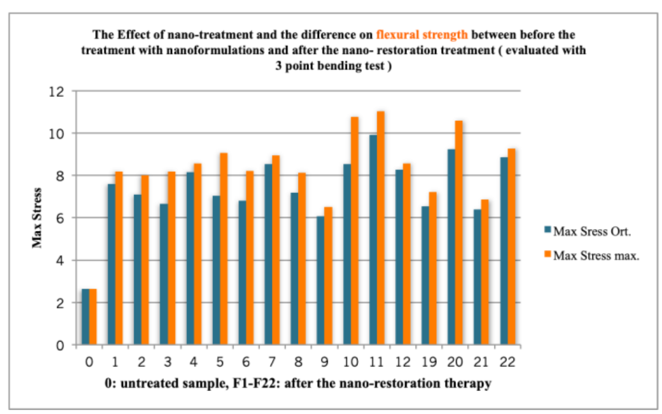

Figure 10. CNT/$Ca(OH)_2$ Nano-composites flexural strength evaluation by 3-point bending test, also effect of colloid stability and dispersion efficiency. [25]

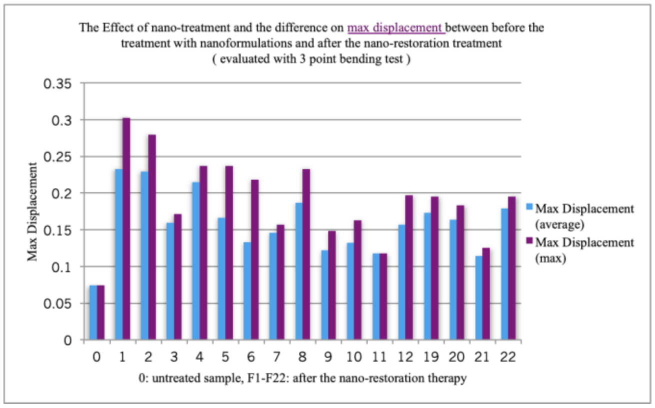

Figure 11. $CNT/Ca(OH)_2$ Nano-composites max-displacement data, evaluation by 3-point bending test, also effects of colloid stability on efficiency [25]

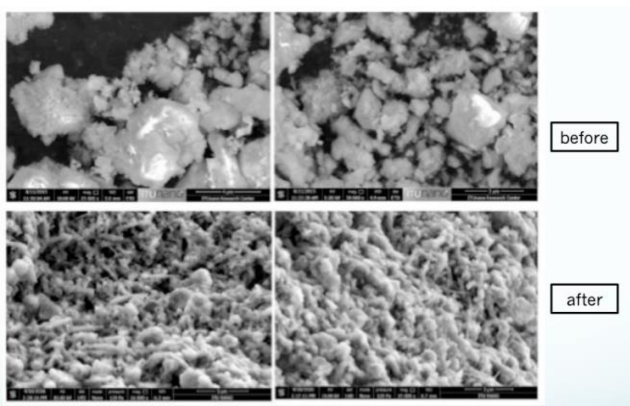

Figure 12. Evaluation of the Efficiency Criteria in nano-tech: SEM analysis of nano-composite treatment, all the defects has been consolidated with the nanoparticles has been shown. (before and after application) [25]

On the other hand, there could be really some certain special cases, especially in architectural restoration applications on real site, that needs extreme safety, and it is evenly worth to spend on it. The fire on Notre Dame Cathedral pointed the issue of the "resistance to fire property" of construction aimed nanomaterials.

Advanced quality and multifunctional nano-materials, such as fire-resistant nanomaterials, or nano-particle absorbed layer based, laminated, functionalized, specialized construction materials, need to be used in symbol and meaningful cultural heritage CH buildings in order to be sure the safety of the building during restoration works [40], [41].

Otherwise, with the inflammable effect of lot of polymer based construction chemicals, that has been widely used in the restoration works, there is always a risk for an unexpected serious fire while the work on site has been going on. With two other examples of this risk, that has been unfortunately experienced in two historical monuments in Istanbul/Turkey: Galatasaray University's fire and Haydarpasa Train Station's fire. [42], [43]. So, even also nanomaterials and choosing the nano-treatment way especially for construction and restoration works, could be expensive, with huge size application zone and application difficulties [44], somehow, in some cases it is needed and must be obligatory to provide enhanced safety.

ACKNOWLEDGMENT

Regarding the figures and graphical data used in this article, with the experience of my master thesis study has been completed in Istanbul Technical University MEMS Nanotechnology laboratories, special thanks for all the support of my master thesis supervisor Prof Deniz Mazlum and co- supervisor Prof Levent Trabzon.

Dott Eng Arch S.E. SUNGUR (author) master thesis study has carried out with the scholarship of TUBITAK Turkish Scientific and Technological Research Council, and have titled with the innovation patent, by the patent number of 2017/17231.

Finally, I dedicate my study to my dear family; my dear dad, I have missed so much and unfortunately have lost recently, MSc. Electrical Eng. Coskun Sungur, lecturer & academician at ITU Istanbul Technical University, my dear mother Serpil Sungur, the luck of my life, and my dear grandmother who have brought me up with all her big heart and unlimited love.

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