Proceedings of the
International Conference on Mechanical Engineering and Renewable Energy 2011
(ICMERE2011) 22- 24 December 2011, Chittagong, Bangladesh

ICMERE2011-PI-172

IMPACT OF CLIMATE CHANGE ON INDUSTRIAL DESIGN PARAMETERS

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Abstract*- The global climate change is expected to make a significant impact on industrial operations in the future. The reliability and operation of industrial machinery will be greatly hampered by the global climate change. At present, some widely used basic design parameters are atmospheric temperature, design temperature, design wind speed, humidity and atmospheric pressure. The wind speed and storm surge will greatly be altered with the increasing planet's surface temperature. This needs to be considered in the design practice for the structural design and machine operations in coastal and offshore locations. Furthermore, the increase in precipitation rate will require change in the design parameters of drainage systems. In this paper, we have identified how the industries can be potentially affected in the future due to the global climate change and what design factors and parameters need to be updated to minimise the impact of global climate change and make current industry to be compliant.*

Keywords: Climate change, Design parameters, Design practices, Impact on industry

1. INTRODUCTION

The design of an industrial plant or process requires the basic design parameters upon which the engineers will formulate the required specifications. Design specifications ensure the operability, functionality, safety and life of the plant or machine. Efficiency and productivity of the plant is also very important to consider in the design phase. The impacts of the plant or machine on environment and the impact of environment on the plant or machine both should be considered in the design phase. Raising concern about the global climate change emphasises the minimization of the impact of the plant or machine on environment. The global climate change is a combination of man made destruction of habitants, flora, and industrialization as ell as natural changes in our planet's atmosphere, which changed the ice-age to present warm world. But the pace of this climate change has been dramatically increased within last few centuries due to the man-maid consequences. After the industrial revolution on 19th century, carbon emissions have been increased rapidly. This increased carbon emission made the global climate vulnerable to human and other living animals. It will make huge damage and disaster to human life, infrastructure, economy and hence the society. In spite of debate about the rate of climate change, there is no doubt about the upcoming consequence of climate change effect in new future. The green house gas emission reduction, adaptation and mitigation can only reduce the impact of climate change effect. For the adaptation of climate change, the design of machine and processing plants also need to consider the climate change in their design parameters. To ensure the smooth operation of machine and plant, the adaptation should be ensured in the design phase. In this paper we have first given a short brief on the consequence of climate change impact. Later we have identified how the industries will be affected by the climate change and what design parameters need to be modified for the adaptation in design phase.

2. GLOBAL CLIMATE CHANGE AND NATURAL DISASTER

The global climate change has increased the natural disaster significantly. Both the intensity and frequency of natural disaster has been increased. The study by Munich ([5], indicated that the natural disasters have increased significantly over the last 50 years especially from 1950 to 2005. An increased trend of frequency of natural disaster from 1950 to 2005 is observed in Figure 1. Between 1950 and 1969, less than four natural disasters occurred yearly. From 1950 to 1969, the natural disaster was mainly the storms, floods and earthquakes, tsunamis and volcanic eruptions. The natural disaster due to extreme temperature was occurred in 1970. Since 1982, the heat wave and wildfire (bush fire) due to extreme ambient temperature have become a common event as a natural disaster. From 1985 to 1999, the number of natural disaster increased sharply. Again 2003 to 2005, natural disaster increased significantly.

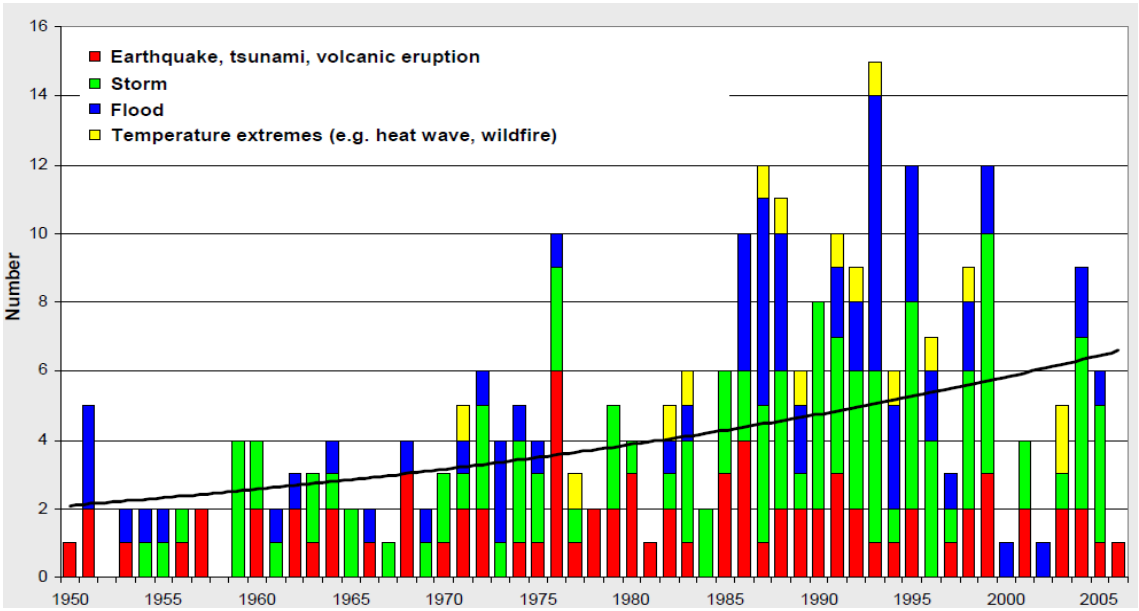

Fig. 1: Trends of natural disasters from 1950 to 2005 (adapted from Munich [5])

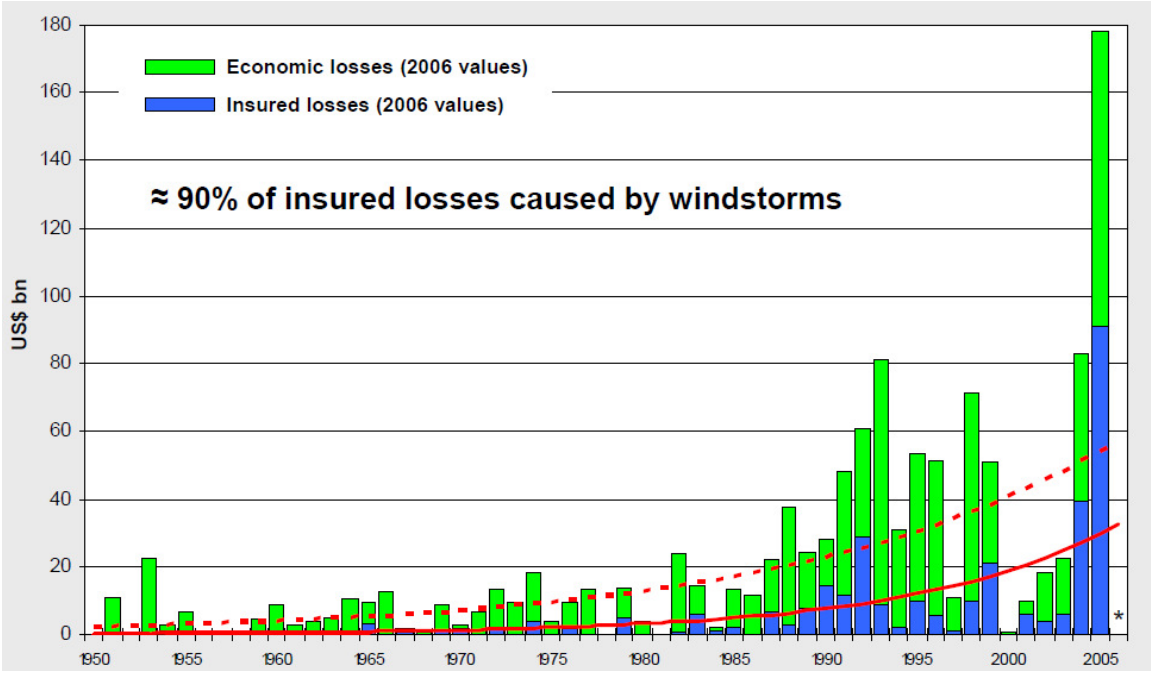

Fig. 2: Trend of economic and insured losses from 1950 to 2005 (adapted from Munich [5])

Figure 1 clearly indicates that the occurrence flood and storm increased rapidly since 1985. The increasing trend of the natural disaster can have direct relevance to the global climate change. Figure 2 shows economic and insured losses due to natural disasters. The economic loss due natural disaster jumped from just above twenty billion dollar on 1987 to near about hundred and eighty billion dollars on 2005. Furthermore, the study of Munich [5]also showed that 70% insured loss is due to the windstorms. This also shows how the natural disaster makes economic losses.

3. IMPACT OF CLIMATE CHANGE ON INDUSTRIES

In Table 1, some direct and indirect impacts of climate change on industry have been depicted. For built environment, direct impact is to ensure structural integrity, safety, service and operation. In all kind of industries climate change has imposed two major facts to consider. One is to reduce the green house gas emission and other is to ensure the reliability of the industrial operation. For built environment like building construction and civil engineering, direct impacts are energy costs, material, structural integrity and the process of construction. Indirect impacts are the new standard and legislation, change in consumer choice

which may lead to change in financial planning. Coastal industries and infrastructures are in a great risk of climate change. For instance, concrete structure will experience increase corrosion. Furthermore, extreme heat wave will cause disruption of operation of commercial and residential building equipments like air-conditioning systems, lit and accelerator and pumping equipment.

Table. 1: Direct and indirect impacts on industrial sector (adapted from [8])

Industry	Direct Impacts	Indirect Impacts.
Built Environment:	a) Energy costs b) External fabric of buildings c) Structural integrity d) Construction process e) Service infrastructure	a) Climate driven standards and regulations b) Changing consumer awareness and preferences
i. Construction.		
ii. Civil Engineering		
Infrastructure Industries:	a) Structural integrity of infrastructures b) Operations and capacity c) Control systems	a) Changing average and peak demand b) Rising standards of service
i. Energy		
ii. Water Management.		
iii. Water and waste water drainage.		
iv. Transportation		
v. Telecommunications		
Natural Resource Intensive:	a) Risks to and higher costs of input resources b) Changing regional pattern of production	a) Supply chain shifts and disruption b) Changing lifestyles influencing demand
i. Pulp and paper		
ii. Food processing		

New building materials need to be introduced to protect from climate change impact in construction process which will increase the construction cost. Another impact would be in energy consumption trend and adaptation for green material and facilities. Current systems, machine and process needs to be more energy efficient, which incur cost of research, application and adaptation. Energy management and planning, water management, waste water drainage, and transportation system are needed to be incorporated during design phase to reduce the economic loss. World energy sector already experiencing significant impact due to climate change. Increase of temperature will create not only problem in cooling system but also increase the demand of power supply for increasing demand of residential and commercial air-conditioning systems. Besides that, new standard and regulation for reducing carbon emission and reducing energy consumption will put indirect impact on these industries. Due to climate change, supply of raw material of some industries like pulp and paper industries, food industries will be affected. It will greatly affect the production of these industries. Natural disaster will hamper the supply of the raw material of resource intensive industries.

4. IMPACT OF CLIMATE CHANGE ON DESIGN PARAMETERS

4.1 Temperature

Change in temperature is a big concern for climate change impact. In designing systems or plants we always consider a design temperature based on an average temperature of a previous stipulated time period. Ambient temperature and liquid temperature are mostly used in specifying the design temperature parameter. In Voiland [9], temperature increase from 1880 to 2000 from four data research institute has been plotted. It is clearly seen in Figure 3 that the temperature increased gradually from 1910 to 2000 with some fluctuations. The data ensures the gradual temperature raise.

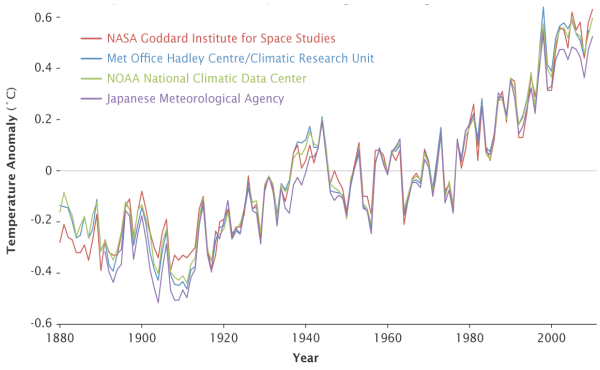

Fig. 3: Increase of world temperature based on different temperature data research institute (adapted from Voiland [9])

4.1.1 Structural Design

Ambient design temperature becomes very important in structural design. In any metal structure like steel structure, ambient temperature needs to be accounted. At high temperature, metal deform which creates failure of structure. In designing a metal structure, designer should not only take account the past historical temperature but also future possible temperature increase. Recent example such as The Southern Star is a

currently nonoperational Ferris wheel in the Waterfront City precinct at Melbourne Docklands in Melbourne, the state capital of Victoria, Australia. It was a project of 100 million Australian dollar and was opened on December, 2008, but subsequently shut down on the following month due to crack development in the structure. The reason was the design fault which was excelled during the heat wave in Melbourne on January 2008 with a temperature of 40 ºC.

4.1.2 Cooling System Design

Cooling systems used in industry is mainly air cooled, water cooled or a combination of these both two. In consideration of air cooled or air and water combination cooling system, the temperature change due to climate change should be consider. In designing of the cooling system of a power plant, climate change on the adjacent cooling water supply sources should be thoroughly investigated. Instead of considering past historical maximum temperature data, projected maximum water temperature during summer season in upcoming centuries should taken account in designing of cooling system of power plants. Furthermore, the impact of climate change on the hydrology of cooling water supply source should be considered. Possibility of increasing drought period in summer season should also be considered in designing cooling system. The increasing trend of atmospheric temperature should also be considered in design phase.

4.2 Corrosion Allowance

Corrosion of metal and concrete structure can be affected by the climate change. In pipe, machine or any metal structure, the corrosion allowance is considered to calculate the required thickness. Increased salinity in the water can increase the corrosion allowance. If the cooling water supply resource of a power plant will be subject to increased corrosion, then all the cooling system machine, metal and structure will be subject to increased corrosion. This also comes to true for cooling water system of all machines or plant which cooling water supply resource will be subject to increased salinity due to climate change. Therefore, for the designing of machine, piping system or steel structure of climate change vulnerable area, corrosion allowance factor should be taken account on regard of sea water instead of corrosion allowance of normal water. Beside this, atmospheric corrosion will be significantly evident due to increased precipitation in coastal area. For atmospheric corrosion three main factor constitute the main reason for the effect, which are mainly: a) the amount of time that exposed surfaces remain wet at the site, b) the amount of chloride from the sea that reaches the surfaces and c) the amount of industrial pollutants (mainly acids) that reach the surfaces. Climate change may create a considerable impact on carbonation-induced corrosion for early constructed concrete structure like bridges. Wang et al. [7] studied the bridge constructed in 1925 in Sydney has only 29 mm concrete cover. They found that the probability of corrosion initiation is 72, 67 and 63 percentage points by 2100 for A1FI, A1B and 550 ppm (parts per million) stabilisation emission scenarios respectively, in comparison with 51 percentage points estimated in the absence of climate change. So, the probability of increases are 21, 16 and 12 percentage points, or an equivalent increase of 41%, 31% and 14% in percentage terms due to climate change. Furthermore, the probability of corrosion damage is 63, 60 and 55 percentage points in comparison with 44 percentage points estimated in the absence of climate change, which is a significant impact due to climate change.

4.3 Wind Speed

In coastal area, the wind speed will be increased significantly due to global climate change. For the design of structure in the coastal areas, this increased wind speed should be considered. Due to climate change, the intensity of cyclone and wind storm will be increased. Therefore, in calculation of structures in coastal areas, the projected increase of wind speed should be taken into account.

4.4 Humidity and Precipitation

Humidity and precipitation both will be increased significantly in the up coming century. Increased precipitation will create problem of drainage of storm water. It will also increase the risk of flooding. On July/August 2005, India experienced its worsen flood in its history due to a record level precipitation of 944 mm rain within 24 hours. This incurred 5 billion US dollar economic loss. Hurricane Katrina on 2005 made 125 billion US dollar economic loss in USA. For this reason, the design of plant facility drain water system should consider this increased precipitation rate. Furthermore, the humidity also relate to the reliability and safe operation of instruments. Instrumentation designing should consider the effect of increasing humidity level.

4.5 Plant Height

Plant height is a very important factor which should be considered carefully in design phase. In coastal areas, where there is a great chance of inundation due sea level rise, plant height should consider the climate change impact. All the area of plant should be high enough to eliminate the effect of sea level rise. This height should be determined by operation period, project life time and projected sea level rise in this period. Also the valve, instrument should be at a height to eliminate damage due to increased flooding. A flood safety wall around the plant can be designed to reduce the risk due to flood.

4.6 Ingress Protection and Water Resistance

Ingress protection of equipment and instruments is very important for plant safety and reliability of operation. Increase precipitation, increase wind storm, flood will require to increase the ingress protection of instruments and equipments. Furthermore, plant in flood prone area should be water resistance to eliminate the damage due to increased flooding.

4.7 Plant Transportation and Material Handling Facility

For successful operation of industrial plant, raw

material and processed product transportation facility is very important. For instance, if an industrial plant material transport way is going to be subjected to inundation and storm surge, the operation and production of the whole plant will then be shut down. Furthermore, if an industrial plant material transport system is through river way which will be subjected to increased erosion, flood and drought, and then the whole plant operation will be hampered due to global climate change. So in designing an industrial plant, the designer or planner should ensure the reliability and operability of the plant transportation system in accordance with future climate change impact.

5. Concluding Remarks

Global warming and climate change is becoming the key concern for socio-economic life of human and its property for upcoming centuries. Beside these, reducing the green house emission, we also have to formulate an effective way of adaptation and mitigation quickly. For a stable economic growth, smooth operation of industries and plants are essential. A smooth operation of industry will not only ensure economic growth but will also ensure the growth of society and hence the country. There is no doubt that the climate change will make a significant effect on industrial plants. The only way that we can continue the industrial production and eliminate climate change effect, is by adapting the climate change impact in design phase. Basic design parameters like temperature, wind speed, humidity, and precipitation should be considered in design phase. A state-wide assessment can be made which will identify the change in basic design parameter in that specific region. Later these parameters can be amended for adaptation in design phase for new installation of industrial plant. Existing industries can be modified for long operational time considering the climate change effect. By this way we can minimise the impact of climate change in industrial establishment and operation.

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