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## Scientific Advisory Board

# *Contents*

**Research Article**

# DOI Numbers

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# *From The Editor*

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*EJEAS was established with the intention of promoting scholarly communication all over the world in a more effective manner. Our aim is to establish a publication that will be abstracted and indexed in the Engineering Index (EI) and Science Citation Index (SCI) in the near future. The journal has a short processing period to encourage young scientists.*

***Prof. Dr. Hasan HEPERKAN***
***Editor***

*Research Article*

# HOW TO PERFORM A RISK ASSESSMENT STEP BY STEP FOR OCCUPATIONAL HEALTH AND SAFETY[1*]


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***ABSTRACT***

*The use of risk assessment methods carried out in enterprises within the framework of Occupational Health and Safety differs from sector to sector today. With the Labor Law No. 4857 and the Occupational Health and Safety Law No. 6331, businesses that are obliged to make risk assessments regardless of their scale are trying to find appropriate methods in order to apply and obtain more reliable and accurate results. The differences between the results of the methods; In risk analyses performed at decision points where experts are inadequate or hesitate while applying the methods, the results of erroneous prioritization of hazards and misclassification of related hazards emerge. In this study, it was emphasized that how risk assessment should be done on the basis of engineering, and which parameters should be considered in the basic steps. Thus, a road map has been drawn to help minimize work accidents and occupational diseases by evaluating the risks that may occur in the workplace environment in a more scientific and systematic way.*



***Keywords:*** *Risk, Risk assessment, Risk analysis, Occupational health and safety*


## 1. INTRODUCTION

Risk assessment is simply prior to expiry or tax valuation, without a simple estimation of what will be delivered in the trade. According to Peter L. Bernstein, risk management and the history of risk are traced back to the games of bone and dice that were played by the Ancient Greeks and Arabs. Bernstein states that the games in question are derived from


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the fear of “hazard” from the expedition to Europe with the crusaders and even from the “al zahr” meaning six in Arabic [1].

Terje Aven, on the other hand, mentions that the basic rules of risk assessment in the modern sense were determined in 1970 and 1980, and he mentions that today, risk analysis methods are applied in many subjects from ecology, environment, occupational safety and law [2].

Risk analysis also constitutes the most important part of the systematic of the Occupational Health and Safety Law No. 6331 (OHS Law). After the Occupational Health and Safety Law came into force in 2013, the Occupational Health and Safety Risk Assessment Regulation (Regulation) was issued and the details of the risk assessment outlined in the OHS Law were determined. Today, there are many studies on risk assessment and management; There are also international standards ISO 31000 and ISO 31010 describing the methods in question. Risk and hazard definitions are terms that should be well known before starting risk assessment studies. Risk according to the regulation; defined as the probability of loss, injury or other harmful consequence resulting from the hazard; the definition in question is close to the definition of risk in standards and international documents. The regulation defines hazard as “the potential for harm or damage that exists in the workplace or may arise from outside that may impact the employee or the workplace.” The steps of risk assessment for all workplaces are described in the regulation, beginning with the design or establishment stage, identifying hazards, identifying and assessing risks, deciding on risk control methods, documentation, updating the work done, and renewing when necessary.

As it is known, in most of the regulations that came into force in accordance with the Labor Law No. 4857, the assessment of occupational health and safety risks is a legal obligation. In addition, the OHSAS 18001 Occupational Health and Safety Management System Standard also requires a risk assessment [3].

The importance of the quality of the work on the assessment of occupational health and safety risks in terms of the prevention of work accidents and occupational diseases is obvious. However, the biggest problem experienced in risk assessment practices both in developed countries and in our country is; There is no agreed method on how risk assessment should be done. Currently used in occupational health and safety risk assessments; Although many methods such as What if, Job Safety Analysis, Failure Mode and Impact Analysis (FMEA), Hazard and Operability Studies, Preliminary Hazards Analysis, Fault Tree Analysis are used, none of these methods are sufficient for a holistic assessment of an organization’s occupational health and safety risks [4].

Therefore, considering the risk assessments made in practice; Some very inadequate and some extremely complex risk assessments can be encountered. On the other hand, since the assessment of occupational health and safety risks is not only a work that should be done by experts, but also requires the participation of the workforce, the method to be applied must be a simple, easy-to-understand method that will lead to detailed results [5].

The purpose of this statement; It is the presentation of a practical 10-step approach developed for the assessment of occupational health and safety risks in an organization. Although the method in question has been developed especially for workplaces with 50 or more employees and counted from the industry, the contents of the steps can be applied to any workplace by changing the contents of the organization when necessary.

## 2. WHY A RISK ASSESSMENT MUST BE DONE?

At the point we have reached today, risk management and assessment constitute the most important element of the philosophy of a new approach to occupational health and safety. The most important reasons for this can be listed as follows. The old approach to OHS was based on hazard-based thinking.

The new approach is based on risk-based thinking. In the old approach, personal protection measures came to the fore rather than collective protection measures. In the new approach, collective protection measures, which we call proactive and preventive measures, gained importance. While in the old approach, the contribution of professional experts who were trained on OHS is not legally required, in the new approach, it is obligatory to receive services from OHS experts for workplaces that are considered to be industry and employ 50 or more workers. While the old approach did not certify that work equipment will not harm human health in manufacturing, in the new approach, the CE certification system, which provides the way to safely manufacture work equipment in manufacturing, has been made mandatory. For the reasons listed here, one of the basic principles of the new approach has been risk assessment. Because risk assessment is a scientific study to determine the precautions to be taken within a preventive logic without paying a price. Workplaces and even our daily environment are full of dangers and the risks that these dangers may cause. This is what we are faced with, sometimes made safe by preventive measures that will not harm us. For these reasons, we do not perceive them as a risk for ourselves. Likewise, all the equipment, facilities, and energy sources we use for production purposes in the workplaces are constantly tried to be made safe in a way that will not harm the employees. In risk assessment studies, it is the whole of the studies carried out to determine whether this safety equipment is sufficient and if not, what new measures to be taken are.

Today, countries have made a concerted effort to limit the material and moral losses caused by workplace accidents and occupational diseases, as well as to recoup the material values lost in this manner. Developed countries that take a scientific approach to occupational health and safety have been able to decrease these losses to very low levels. However, in our country, which is a growing country, the direct and indirect costs of workplace accidents and occupational diseases impose a significant financial burden on the national economy [6].

Making a risk assessment is the scientific technique to begin preventative efforts in respect to the identified high-level hazards. The workplace is riddled with both obvious and subtle hazards. The greatest science-based study to follow to foresee the dangers from these hazards and eliminate the unacceptable is risk assessment.

## 3. RISK ASSESSMENT STEPS

### 3.1 STEP 1: ESTABLISHING THE RISK ASSESSMENT PROJECT TEAM

A "Project Team" is established, which includes representatives from all units within the scope of risk assessment in an organization, who have information about all activities carried out in those units, the occupational health and safety officer and the workplace doctor. Preferably, the task and responsibility of the "Project Coordinator" is given to the occupational health and safety officer. The task of the Project Team; It should be ensured that the risk assessment studies to be carried out in the organization are carried out in a timely and effective manner by coordination [7].

### 3.2 STEP 2: DEFINING THE AREAS AND ACTIVITIES FOR RISK ASSESSMENT

All activities carried out by the members of the Project Team in all areas within the facility and around the facility, which are within the responsibility areas of their units in the organization, and in each area;

- Activities under normal conditions
- Occasional activities such as cleaning, commissioning, stopping, maintenance-repair
- Supplier, subcontractor, etc. activities and
- Visitor activities including defined.

In addition, facilities, highways, railways, airports, settlements, rivers, etc. that may create risks for the organization outside the workplace. All locations are defined [7].

Buildings should be viewed as a source of danger when discovering danger, particularly work equipment and systems, and the issue of how damage will occur from this source should be asked. The answers to this question will disclose the threats that will occur as a result of that source. This way, it is possible to predict that more than one risk will arise from a single cause. In other words, several dangers emerge from a single cause, and multiple risks emerge from each hazard. Within this systematic approach, hazards in a workplace can be detected in the following ways [8]:

a- Reviewing past records:

- Examining the ambient measurement reports,
- Examining work accident and near miss reports,
- Evaluation of the annual activity reports of the OHS Board,
- Examining the reports of public and private auditors,
- Examining the technical periodic control reports

b- Examining the current situation:

- List of chemicals, physical and biological factors
- Inspection of work equipment,
- Examining the working environment,
- Examination of ergonomic conditions
- Review of business activities
- Evaluation of manufacturer data
- Examining the organization

c- Examination of legislation and literature

- Examining the OHS legislation,
- Examining other relevant legislation,
- Examining the standards,
- Examining ILO norms,
- Literature review,
- Evaluation of manufacturer data,
- Benefiting from expert comments

### 3.3 STEP 3: ESTABLISHMENT OF RISK ASSESSMENT TEAMS AND CREATION OF RISK ASSESSMENT PLAN

OSHA (Occupational Safety and Health Administration) indicates that one of the most important factors that cause accidents in the workplace is the inability to detect the hazards in the workplace [8]. The first phase of the risk assessment process is the hazard identification phase. As stated above, it is necessary to determine the existing hazards in the workplace in accordance with the hazard definition. To this end, the Regulation states what information will be collected to identify hazards. It described the identification of hazards in the simplest way in the risk assessment guide published by HSE (Health and Safety Executive), walk around the workplace, and think about what could harm workers. In addition, it recommends checking the machine information provided by the manufacturer, the records of past work accidents and occupational diseases, non-routine operations (such as maintenance and repairs), and long-term harmful factors (such as noise, exposure to dangerous dusts) [7]. In the 8th article of the regulation, the places to look for to identify the hazards are listed as a minimum. Before the risk assessment is carried out, the issues stated in the 8th article should be checked and the hazards should be determined.

In order to evaluate the risks of the areas defined by the project team and the activities carried out in these areas, risk assessment teams are formed, preferably consisting of a maximum of 5 people, in terms of effectiveness. The following points are considered in the formation of Risk Assessment Teams [9,10,11]:

- It is preferred that the occupational safety officer and the occupational physician, who have knowledge in the field of occupational health and safety, participate in the work of all teams that make risk assessments. However, if the workplace is very large and it is not practically possible for the occupational safety officer and the occupational physician to participate in these studies, the occupational safety officer and the occupational physician will check the risk assessment studies of each team. In the next steps after this step, they make the necessary additions or corrections together with the team, to the place where the activity is carried out. Any risk assessment study that is not approved by the occupational safety officer and the occupational physician will not be put into effect.

- At least one of the persons to be assigned in the Risk Assessment Teams will be a person who works in the field or activity to be examined and has detailed information about the field or activity.

- If there are special risks such as risks related to hazardous chemicals, biological risks, and radiation risks in the area or activity to be examined, at least one of the people who will work in the Risk Assessment Teams will be informed about these risks. If there is no person who has sufficient knowledge about these issues in the workplace, support can be obtained from experts in related fields outside the organization.

- If work equipment is used in the area or activity to be examined, Risk Assessment Teams include people who use the relevant work equipment, people who have technical knowledge about the work equipment, if necessary, and those who are involved in the mechanical and electrical maintenance of the relevant work equipment. If the relevant work equipment is a special equipment and people who have technical knowledge about that equipment are not present at the workplace, support can be obtained from experts about the relevant equipment outside the organization.

- Occupational physicians must be included in the risk assessment team if there is such a case as exposure to hazardous chemicals/noise/vibration/dust/smoke/ray/radiation/cold/heat, use of screened vehicles, manual handling, ergonomic risks that may pose an occupational disease risk in the area or activity to be examined. Task is provided.

- In order to minimize the deficiencies that may arise from business blindness in the risk assessment, it would be beneficial to ensure that at least one person completely independent of the area or activity to be risk assessment is included in the Risk Assessment Team.

- One person from each Risk Assessment Team is given the task and responsibility of coordinating the entire team. After defining the areas where risk assessment will be made in the workplace, the activities carried out in the areas and the teams that will make the risk assessment, a risk assessment plan is created by taking the opinions of the Risk Assessment Teams.

### 3.4 STEP 4: TRAINING OF RISK ASSESSMENT TEAMS

What is expected from each Risk Assessment Team is to define their own areas of responsibility and the hazards and risks related to occupational health and safety of the activities carried out in these areas, to determine the degree of importance of the identified risks, and to evaluate the existence and adequacy of the existing control measures against these risks. For this reason, it is important to provide the following trainings to all risk assessment team members to gain this competence [9,10]:

- Occupational health and safety legislation and other conditions, if any, that are obliged to comply
- The basic rules of occupational health and safety and risk management principles, varying according to the type of workplace
- Evaluation of applied occupational health and safety risks on sample activities in the field.

The said trainings can be given in coordination by the occupational safety officer and the workplace doctor within the organization, or they can be provided by outsourcing the organization.

### 3.5 STEP 5: PREPARATION OF RISK ASSESSMENT TEAMS

Each Risk Assessment Team, which will carry out risk assessment in the areas and activities under the control of the organization, shall obtain the following information to be used in the risk assessment before carrying out the risk assessment work in its area of responsibility [11].

The work steps of each activity in the areas where risk assessment will be made are defined with the logic of process management. E.g; Possible steps of material handling activity with forklift to warehouse may be forklift picking up the material, bringing it to the warehouse and leaving it at the appropriate places in the warehouse. Among the following, those related to the area or activity for which risk assessment will be made are examined [10,11,12]:

- Related occupational health and safety legislation and other conditions
- Dangerous chemicals used, their dangerous properties, safety data sheets, labels, usage, storage, transportation, and exposure types (respiration/skin contact/ingestion), characteristics of their packaging, emergency eye and neck showers and locations, response equipment for chemical substance leaks, gas detectors, alarms, etc.
- Water, energy, packaging, raw materials, etc. Conditions of use, use, transportation, storage
- Types of liquid, solid, gaseous wastes, storage, transportation, and disposal methods
- Used work equipment, user manuals, use and maintenance-repair instructions, dangerous features during use and maintenance, machine protectors, if any, emergency stop buttons, sensors, etc. Features and placement of control buttons, conditions for the use of work equipment, characteristics of the environment in which work equipment is used, etc.
- In manual handling works, the load carried, the mode of transportation, the frequency of transportation, the transportation distance, ambient temperature, humidity, ventilation, etc. Conditions and characteristics of the ground
- The characteristics of the electrical installation used, the placement of the control buttons, the maintenance and repair of the electrical installation
- Dangerous properties of the pressure cylinders used conditions of use, transportation and storage
- Forklift, pallet truck, truck, etc. Use of vehicles, usage patterns, movement routes, load they carry, loading patterns, parking areas, etc. Features, speed limits,
- Use of vehicles such as passenger cars, shuttle buses, characteristics of

movement routes, parking areas, speed limits

- Characteristics of the task and work environment that requires working at height
- Characteristics of the working environment, floor structure, walkways, ventilation, lighting, etc. Conditions
- Near-miss events, accidents, occupational diseases records, statistics that occurred in that area or activity
- Occupational health and safety audit records
- Records of nonconformity/corrective/preventive action regarding occupational health and safety
- Monitoring measurement records such as noise, ambient air, radiation, vibration, lighting
- Existing plans, procedures, instructions
- Employee health surveillance records, statistics
- Personal protective equipment used by employees and their features
- Professional and occupational health and safety training records of employees, personal characteristics of employees, professional qualifications, procedures for selecting personnel and submitting work
- Consistency of the job and job descriptions of the employees
- Safety and health signs available in that environment
- Emergency plans and procedures, emergency teams, emergency response equipment, evacuation routes, exercise scenarios, drill records, experienced emergency records, emergency training records, etc., concerning the relevant area and activity.
- Personnel receiving first aid training, first aid cabinets, materials and
- Any other information that may be required in the risk assessment study

To identify the dangers and risks that may come from places outside the organization that are not under the control of the organization; Methods such as collecting information about places and facilities outside the organization by the responsible team, visiting places outside the organization and, if appropriate, facilities can be used.

### 3.6 STEP 6: IDENTIFICATION OF OCCUPATIONAL HEALTH AND SAFETY HAZARDS AND RISKS

This step is the most important step of the occupational health and safety risk assessment. Because it is clear that it will not be possible to control and manage unidentified hazards and risks [11].

After the preliminary study is carried out by each Risk Assessment Team regarding the areas and activities under the control of the organization, regarding the issues specified in STEP 5, the occupational health and safety hazards and risks related to each step of each activity carried out in the areas and areas that are responsible using the method below. Risks are identified and recorded in an “Occupational Health and Safety Risk Assessment Form” to be prepared [11,12]:

- On-site observation of the relevant area and activity is the most important step in hazard and risk identification. Wherever possible, on-site observations are made by all members of the Risk Assessment Team in the relevant area and at each step of the activity.
- Even if they are in the team, interviews are made with other employees in the relevant field and activity, and their opinions are taken about the OHS hazards and risks related to the area or the activity, the current risk control measures applied against the risks and the additional risk control measures they want to be taken.
- If there are activities that cannot be observed during risk assessment, such as annual maintenance on tanks, interviews can be used as the only way to identify hazards and risks associated with these tasks initially, provided they are observed later during the activity.

After the hazards are determined, the process to be done is the determination and analysis of the risks; In the Regulation, this process is defined as follows: “By considering each of the identified hazards separately, it is determined how often the risks that may arise from these hazards may occur, and who, what, how and in what severity may be harmed by these risks. While making this determination, the effect of existing control measures is also taken into consideration. Quantitative methods are generally used in risk assessment in our country; mostly used methods are 5×5 or 4×4 matrix method and Fine Kinney method. In addition to these, Decision Matrix Method, Fault Tree Analysis Method, Fault Type Effect Analysis Method, Checklist Method, If It Happens Method, Event Tree Analysis Method and Cause and Effect Analysis methods are among the known methods.

Although the methods to be chosen are left to the employer while conducting the risk analysis, it should be determined who, what, and to what extent will be affected in the method to be chosen. Risk is usually calculated as the probability of error multiplied by the result of the error. As stated above, the regulation also requests that who or what will be affected be added to this.

### 3.7 STEP 7: DETERMINING THE SIGNIFICANCE OF RISKS

Once the hazards have been identified, they should be decreased to tolerable levels. Regulation acceptable level; it is described as the amount of risk that, in compliance with legal duties and the workplace's prevention program, would not cause loss or injury. A risk level that is acceptable is one that will not result in loss or injury. The risk-mitigation process includes the processes of planning in accordance with the Regulation, deciding on risk-mitigation measures, implementing risk-mitigation measures, and monitoring practices. During the planning phase, the risks should be prioritized in order of importance, and a battle plan should be devised. The precautions to be taken during the decision-making phase of risk management measures should be eliminated first; if this is not possible, a non-hazardous method, chemical, or equipment should be chosen; and if this is insufficient, the possibility of causing harm should be avoided. The decided control measures should next be applied, and at this stage, the persons who will apply the measures in the workplace should be determined; this issue is critical for determining who is liable in future incidents. While the measures are being implemented, the work and process steps of the measure, the person or workplace section, the start and finish date of the measure, and the start and end date of the measure must be defined. During the implementation monitoring phase, it was mentioned that the implementation procedures should be frequently reviewed and audited by the employer.

The degree of importance of the occupational health and safety hazards and risks defined for each activity is determined by the Risk Evaluation Teams using a sample method and discussed, and recorded in the "Occupational Health and Safety Risk Evaluation Form". Since existing risk control measures do not reduce the severity of risks, it is important not to consider the existence of existing risk control measures in determining the severity of risks. E.g; Giving a seat belt to a staff working at height does not reduce the importance of the risk of falling from a height. Because when the person does not use the seat belt even though it is given; The severity of the risk of falling from a height will be the same as if a seat belt is not provided. The severity of a risk can only be lowered when action is taken to reduce the severity of the risk. E.g; such as enabling people to work at lower heights, reducing the noise level by taking precautions at the source [13].

### 3.8 STEP 8: IDENTIFYING WHO MIGHT BE HARMFUL FROM RISKS

For the protection of persons who may be exposed to risks; It is necessary to determine which people may be exposed to which kinds of risks in order to define the training they should receive, the personal protective equipment and features they should use, the rules they should follow while working, and the health surveillance that they should be kept periodically at the beginning of the job [11,13].

Some examples of people who may be harmed by risks in the workplace are given below;

- Workers
- Operators
- Maintenance and repair personnel
- Subcontractors
- Cleaners
- Administrative staff
- Visitors
- Interns
- Apprentices
- Those around the organization that may be affected by risks

While determining the persons who may be harmed by the risks in the workplace;

- Disabled
- People's experience
- For pregnant women
- For women who have just given birth
- For personnel working alone
- To visitors
- To interns
- Apprentices and
- The work environment is shared with other personnel special attention should be paid. Because they may be more vulnerable than others.

### 3.9 STEP 9: PLANNING RISK CONTROL MEASURES

The existence/adequacy of the existing risk control measures is evaluated for each OHS risk whose significance level has been determined, and additional risk control measures are planned considering the risk control hierarchy stated below [10, 12, 13]:

- Elimination of the hazard (For example, the use of a non-hazardous substance instead of a dangerous substance, stopping the use of a noisy machine, manual handling by mechanical means, etc.)
- Risk reduction (For example, replacing a hazardous substance, plant or process with less hazardous ones, replacing a noisy machine with a quieter one, etc.)
- Keeping people away from danger (For example, not allowing people to work near noisy machinery, etc.)
- Encircling the danger (For example, performing all painting operations in a neat and closed painting booth, covering noisy machines with soundproof plates, putting guards on equipment with moving parts, putting railings on high places, etc.)
- Reducing the exposure of workers (For example, each of 4 people is exposed to noise or a chemical vapor for two hours instead of 8 hours of exposure to one person, etc.)
- Improving the work system (For example, establishing written procedures for the painting activity to minimize evaporation, restricting the access of employees to hazardous areas, etc.)
- Use of Personal Protective Equipment (For example, use of helmets, gloves, safety glasses, protective clothing, earplugs, etc.)

When planning risk control measures, first of all, it should be ensured that the relevant legal regulations are met. The scope of risk control measures is quite wide and should be handled with a risk management approach. Below are some examples of administrative or technical risk control measures [12,13,14]:

- Defining and informing all employees of their duties, authorities and responsibilities regarding occupational health and safety in the workplace
- Establishing and implementing procedures and instructions for performing risky activities under safe conditions.
- Preparation and implementation of the instructions for safe use of work equipment
- Implementing preventive maintenance on work equipment

- Protective use in work equipment with moving parts and risk of throwing parts.
- Periodic checks of pressure vessels and lifting equipment
- Use of emergency stop systems in work equipment
- Subjecting the personnel to health surveillance at the beginning and periodically in line with the risks they are exposed to
- Staff, subcontractors, suppliers, etc. Informing and educating them about the risks they may be exposed to in the workplace and risk control measures
- Ensuring the professional qualifications of personnel working in risky activities or managing risky activities
- Establishment of consultation and communication mechanisms in order to receive feedback from the personnel regarding risks and risk control measures.
- Establishing mechanisms to be aware of the changes that may occur in the legal legislation and to ensure compliance continuously
- Implementation of the work permit system
- Providing adequate lighting to risky areas
- Creation of internal traffic routes and traffic rules
- Ensuring that dangerous chemicals are stored under appropriate conditions
- Providing ventilation in areas where hazardous chemical vapors are likely to occur
- Providing personal protective equipment
- Creation of emergency plans
- Provision of emergency response equipment
- Provision of emergency lighting equipment
- Establishment of emergency evacuation routes and assembly points
- Creation of emergency communication equipment
- Conducting exercises
- Periodic monitoring and auditing of workplace precautions to check that they are used properly and provide the expected risk reduction.

While planning risk control measures for risks that cannot be prevented at the source during risk assessment, it is important to pay attention to the reasonable application approach. In most cases, it may be possible to reduce the risk to a very low level. However, it is very important that the risk control measures taken are reasonable. For example, a car can be driven continuously at 30 km/h on the road. This speed can reduce the chance of a collision for the driver and may result in fewer injuries to the driver when a collision occurs. However, driving at 25 km/h is so inconvenient for the driver and other road users that eliminating this inconvenience outweighs the benefits of risk reduction. Therefore, driving at 30 km/h is not a reasonable practice. This principle also applies to work-related studies.

If the cost associated with workplace measures in terms of time, money, effort or inconvenience outweighs the benefits of risk reduction, it is not reasonable to apply that workplace measure. Likewise, it is not a reasonable practice if any of the workplace measures currently implemented in the workplace takes too much time, requires too much effort and is too laborious. Because in this case, there is a risk that the relevant measures are not implemented by the personnel who are exposed to the risk for this reason alone. In this case, the thing to do is; It is the immediate search for less cumbersome and more practical solutions and continuing the old practice until a better solution is found.

Among the risk control measures defined by each Risk Assessment Team in line with the aforementioned, those present in the workplace and the risk control measures to be taken are recorded in the "Occupational Health and Safety Risk Assessment Form". It is preferred that the occupational safety officer and the occupational physician, who have knowledge in their fields, participate in the planning of risk control measures carried out by all teams. However, if their participation is not practically possible, the "Occupational Health and Safety Risk Assessment" forms not approved by them will not be put into effect [14].

### 3.10 STEP 10: REVIEWING RISK ASSESSMENTS AND REVISING AS NECESSARY

It is also necessary to document the stages of identifying hazards, analyzing and combating risks. The regulation has specified the information that must be in the documentation of the risk assessment and these are [3];

- The title, address and employer's name of the workplace,
- Names and titles of the performers, and the document information of those who are occupational safety specialists and occupational physicians, given by the Ministry,
- Date of execution and validity date,

- If the risk assessment is made separately for different departments in the workplace, the name of each,
- Identified sources of danger and hazards,
- Identified risks,
- The method or methods used in risk analysis,
- Analysis results, including the order of importance and priority of the identified risks,
- Corrective and preventive control measures, the dates of their realization and the risk level determined afterwards

The risk assessment should be reviewed and updated on special occasions and periodically. The special cases where the risk assessment should be reviewed are mainly; It can be listed as buying new machines in the workplace, starting to work with new substances, putting new methods into practice, an accident or a near-miss event, or an occupational disease [14].

## 4. ERRORS MADE IN THE RISK ASSESSMENT

Employers can make various mistakes in the stages of risk assessment, preparation, identification of hazards, fight against risks, and documentation, and these mistakes can put the employer at a disadvantage before the administration or the courts. Considering the mistakes made during the risk assessment stages and their possible consequences;

Phase of identifying hazards;

- The hazards in the workplace should be characterized in the most basic form possible by visiting the workplace and utilizing the resources indicated in the Regulation. If labor inspectors discover this condition during their inspections, they may request an administrative fine, and if an accident occurs as a result of a readily recognizable and unidentified hazard, the employer's fault rate rises.

Phase of Identification and Analysis of Risks;

- Risk scores are produced after evaluating the dangers and sources of danger in the workplace, taking into account the potential of damage from existing hazards, the number of individuals who will be affected in the event of damage, and the magnitude of the harm. The most typical errors made at this step include determining risk scores without considering objective criteria and standards, resulting in the formation of risk scores that contradict each other.

Phase of Combating Risks;

- The phase of dealing with risks is the most important and most neglected phase of risk assessment. The legislation requires that various measures be taken to eliminate the hazards identified during the fight against risks and that the risk scores be reduced to an acceptable level where there is no possibility of loss or injury. After the risk scores are determined in practice, the implementation of the measures to be taken to reduce these scores to an acceptable level is neglected and it is thought that the risk assessment ends with the determination of the risks. This situation leads to the thought that the risks are known but not eliminated in the post-work accident trial, and this increases the employer's fault significantly. As a result of not selecting the responsible and responsible personnel and unit in eliminating the risks, it causes confusion of authority in the workplace and may cause people who are not faulty to be responsible for work accidents.

Phase of Documentation and Renewal;

- During the documentation phase, not all of the issues in the regulation, especially in the implementation, are included in the evaluation, there is no support staff's signature, and not every page of the evaluation is initialed.
- In the renewal phase, the risk assessment is not renewed partially or completely, although the changes specified in the regulation occur at the workplace.

## 5. CONCLUSION

In our country; There are many businesses that work without rules and supervision, carry high risks, are far from engineering technique and science, and are operated in completely primitive conditions without the supervision and supervision of trained technical personnel. There is always the risk of an accident in these businesses, and it is a known fact that accidents are not destiny but can be prevented by taking appropriate precautions [15].

There is no world consensus on the ideal method of risk assessment. However, risk assessment is required by law in all developed countries. However, in cases where a standard is not determined on how the risk assessment should be made, it is discussed whether imposing a penalty in case it is not done is in accordance with the legal principles. Similar discussions are taking place in our country. Although risk assessment is required in many regulations, it is not specified how it will be done. Despite this, it is known from events that Labor Inspectors force businesses to make risk assessments, try to have a model applied in line with their personal opinions, and impose fines if they do not do so. In order to ensure a fair application, it is necessary to determine how risk assessment should be done in the legislation and to provide a standard. Errors made during the above-mentioned risk assessment stages increase the responsibilities of employers, employers' representatives, occupational safety specialists and workplace physicians, and administrative fines may be imposed due to these deficiencies in administrative audits. As a result; It is very important to carry out risk assessment studies in all workplaces and to implement the corrective, preventive and control measures determined as a result of these studies in the workplace for the prevention of work accidents and occupational diseases in that workplace. In our country, the public, employers and employees should be sensitive to this issue and show the necessary care for the formation of an OHS culture.

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*Research Article*

# APPLYING WIND VIOLENCE AND SOLAR RADIATION FORECAST FOR KADIKÖY-GÖZTEPE DISTRICTS[1*]

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***ABSTRACT***

*Although energy topic is one of the most difficult issues in physical sciences, in its simplest definition, each and every one of our surroundings is almost a source. The recent search for energy is increasing day by day and human beings are looking for new energy sources. Since the early 1990s, Turkey has been guiding system energy planning and energy towards the greatest. This latest has a great enthusiasm for new energy and energy technologies. Based on the current record potential in Turkey and Asia, the power has been transferred to 4 Pos. In terms of solar potential, when you compare it with energy potential in Mediterranean Region, it is seen that we have the potential to match the potential in Turkey. In contrast with fossil fuels polluting the atmosphere, an environmentally friendly energy production is gradually increasing. We can realize the potential of the energy resources that we can benefit from the related projects. In this study, the Asian side of Istanbul (Kadıköy-Göztepe) and at the near vicinity, it was analysed time variations of solar radiation and wind speed. The reliability of ANN model for wind speed and solar radiation prediction is better in summer than other seasons. As a conclusion, the relation between ANN model results and observation for solar radiation (r=0,98) is higher than the correlation coefficients (r=0,72) for wind speed modelling. The reason is that the angles of the incoming solar radiation and the wind speed blowing from the sea are high in the coastal areas and high parts of Istanbul.*

**Keywords:** *Artificial Neural Networks (ANN), wind energy potential, solar radiation, solar-wind hybrid/hybrid systems.*

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# 1. INTRODUCTION

The energy problem continues to take the first place on the agenda of our country. In international relations, energy has an important position in determining either cause or effect in political, commercial and military fields. Wind energy potential is actually one of the oldest sources of energy, used since 2800 BC. This energy has been used mostly for pumping water and obtaining electrical energy in rural areas until recent years. Today, an alternative source of energy generation is taking place in the energy sector [1][2].

Among the renewable energy sources, the wind energy potential is an alternative energy type to the energy obtained with fossil fuels, which has been developing rapidly in our country recently and that about 70 countries in the world benefit from electricity production. At the end of 2007, the total installed wind power potential in the world is 93,864 MW. A total of 57,136 MW of this installed power belongs to the European continent [3][4][5]. In Turkey, the total installed power is only 146 MW [6]. Turkey is the country with high wind energy potential in Europe with 83,000 MW, [7]. Turkey reached a wind energy capacity of 15,000 MW in 2017 and 15,500 MW in 2018 [8]. In this sense, studies and projects are carried out for the establishment of wind power plants, especially on the coasts of the Marmara and Aegean regions, and statistical analyses are carried out by obtaining wind data from suitable places by the Electricity Works Survey Administration (EIE).

In order to analyse the wind potential of the sample region, hourly wind intensity information in that region should be measured for at least one year. In addition, in order to achieve more accurate and sensitive results, attention should be paid to the absence of near-environmental obstacles around the measurement station that will affect the data to be obtained in these measurements [9]. Solar energy is becoming more popular in developed countries because carbon emission is not necessary and other energy sources cause climate change. In recent years, many countries have invested in renewable energy sources. Especially the main countries that use renewable energy sources in the world are Switzerland, Sweden, Costa Rica, and Germany. Brazil, Germany, and Russia are other investor countries investing in renewable energy resources. Bioenergy, geothermal energy, hydroelectricity, ocean sea-wave energy, solar energy, and wind energy are six important renewable energy sources [10]. These energies are clean energy sources. Renewable energy provides new business opportunities apart from its environmental benefits. Hydroelectric technologies are old technologies and have been used for a very long time. On the other hand, studies on wind and solar energy are developing rapidly over time. Solar energy is the most important renewable energy source that has the potential to meet the production need. The popularity of this energy source is constantly increasing due to its various benefits to humans and the environment. Technologies developed to benefit from solar energy not only increase the efficiency of solar energy, but also reduce many infrastructure costs [11] [12].

Renewable energy-based generation facilities in the Turkish electricity system especially supported solar and wind energies. Turkey has high wind and solar energy potential. Central parts of Turkey in general have high solar energy potential, while high wind energy potential is observed in the western parts of Turkey. As of the end of 2010, Turkey was in the 17th place in the worldwide wind energy ranking with its 1274 MW production. Turkey showed a great growth rate at the end of 2009 and made itself known in the

European wind market [13]. The growth rate in 2009 was recorded as 138.9%. Growth continued in 2010, but a lower growth rate was observed compared to 2009. At the end of 2010, a growth of 59.9% was realized. Despite this, Turkey entered the top 10 in the world in terms of growth rate and took its place in the 5th place [14]. In the global energy crisis triggered by the COVID-19 pandemic, which put pressure on the whole universe in 2020, alternative ways were preferred in electricity generation methods, and this option increased solar energy and electricity production. In 2020, approximately 90% of the additional electricity generation capacity will be realized in renewable energy. Less than 10% will come from gas and coal. The trend is that green electricity is expected to be the largest source of power by 2025, surpassing electricity from renewable energy and coal for electricity by 2024.

The share of solar energy in meeting the electricity supply, which will increase in the next 10 years, is expected to increase by 12% on an annual basis starting from 2023. Solar and wind energy, which has a market share of 8% in 2019, is expected to reach 30% in 2030. In 2025, the 275 GW coal power plant will be decommissioned and replaced with renewable solar and wind power plants. This figure corresponds to 13% of the global coal production capacity. This increase will reduce the solar energy investment cost rates to 42% below the 2019 data, to 3.9 cents/kW/hour, and will make it 80% less costly than coal investments. The report from the US Department of Energy, dated Tuesday, August 17, 2021, estimates that the current status of the tax relief plan for renewable projects and utilities will exceed 40% by 2035, while the current status of the new energy plan will exceed 40% by 2035. It is 3%. This action plan is expected to create 1.5 million new jobs in the US and the manufacturing and industrial sectors are expected to be a nasty force.

According to the International Energy Agency, offshore wind power is capable of meeting all of the world's electricity needs and uses it as a "game" for energy systems. The Paris sales energy agency aims to compete with fossil energy within the year after overseas sales plummet. The IEA estimates that the global average power consumption generated by offshore wind will fall by 40% by 2030. At the same time, major cities in France are working to reduce their use in major cities to net zero by 2050.

# 2. DATA AND WORKING AREA

Wind speed and solar radiation data records at 2016 were analysed. The wind speed and solar radiation for the following year were estimated after it was obtained from the Ministry of Environment, Urbanization and Climate Change, Turkish State Meteorological Serice.

## 2.1. WORKING AREA

Göztepe has been selected as the study area.

## 2.2. DATA

The data sampling rate is for every ten minutes. Variables measured at Göztepe Kadıköy station; the air temperature is 2m ($^{o}$C), solar radiation (W/m$^2$), UV radiation, wind speed (km/h) and 5 cm above surface temperature ($^{o}$C). The data covers the period between January 1, 2016 and December 31, 2016. Meteorological variables at the station are shown in Table 1 below.

**Table 1.** Sampling Data Set

| **Station Name** | **Date** | **Air Temperature 2m °C** | **Solar Radiation W/m2** | **UV Radiation indis** | **Wind speed km/saat** | **Wind direction** | **Surface temperature 5cm °C** |
|---|---|---|---|---|---|---|---|
| Kadıköy-<br>Gözdetepe | 2016-06-01 00:00:00.000 | 18.9 | 7 | 0.1 | 3.2 | 1 | 16.1 |
| | 2016-06-01 00:10:00.000 | 18.3 | 15 | 0.3 | 1.6 | 3 | 15.6 |
| | 2016-06-01 00:20:00.000 | 18.3 | 23 | 0.2 | 0 | 3 | 16.7 |
| | 2016-06-01 00:30:00.000 | 18.3 | 34 | 0.1 | 1.6 | 0 | 17.2 |

It is observed at regular intervals at Göztepe-Kadıköy Station. The missing data is completed by compiling the arithmetic mean of the neighbour values. The data to be obtained in this article are given in ten-minute intervals. Seasonal data was calculated by collecting all the data of the months of that season. At the Göztepe Kadıköy Meteorology Station of the study area, the air temperature at 2 m above the mean average ground level is calculated as ab °C, the value of solar radiation is W/m$^2$, UV radiation, wind speed is calculated as km/h and the temperature at 5 cm above the ground is °C.

# 3. METHODOLOGY

In this part of the research, the ANN method that was used to predict the potential of solar radiation and wind speed analyses will be presented. Moreover, the open source WEKA application will be introduced to identify attractive variables.

## 3.1. ARTIFICIAL NEURAL NETWORKS

In this section, information about the diagnosis, general structure and elements, architecture and training of ANN will be given.

## 3.1.1 ARTIFICIAL NEURAL NETWORK DEFINITION

In this part of the research, the artificial neural network method will be used to predict solar radiation and wind speed.

ANN is an artificial system that tries to imitate the working structure of the human brain. Artificial neural networks look at the examples of events, make generalizations about the event using these examples, collect information, and then make decisions using the information they have learned when they encounter examples that they have never seen.

ANN is inspired by the human brain. It is based on mathematical modelling of the human learning process. ANN studies first with the modelling of neurons, biological units of the brain. ANN consists of initiated connecting with each other in various ways and is usually arranged in layers. In accordance with the brain's learning process, ANN is a parallel distributed processor capable of collecting information after a learning process, storing and generalizing this information with the weight of the connection between cells [15].

The learning process includes learning algorithms that renew the ANN hidden a year to achieve the desired goal. ANNs' perform automatically with their abilities (ratio, performance, accuracy) such as obtaining, creating and discovering new information by training [16].

Contrary to methods based on traditional models, even when the relationships between variables are unknown or very difficult to understand, they can capture the relationships between these variable data and learn from examples. ANN is widely used in applied studies to solve real world problems, [17].

ANN uses previously obtained data samples to make predictions about the future. It creates a mathematical function (model) for the problem by training the existing historical data [18].

## 3.1.2 FEEDBACK NEURAL NETWORKS

In the network, one or more processor element outputs are given on their own or as inputs of other processor elements. Generally, these networks are located on a delay element. It is the element that is responsible for carrying the activation value in the intermediate or output layer to the iteration of the other stage. Feedback networks can be between processor elements in a layer, or there may be processor elements between all layers. Because of this feature, feedback networks show a dynamic feature. These networks do not show a linear feature. Thanks to these functions of feedback networks, artificial neural networks with different structures and behaviors are available. The working principles of these networks have a complex structure. Because they are only capable of dynamic memory, they give good results in predictions.

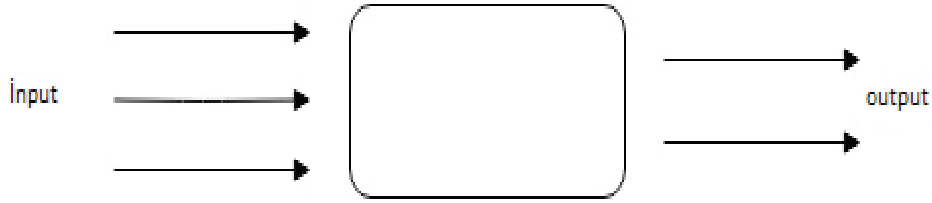


**Figure 1.** Symbolic representation of the neural network model

The neural networks simulation in the figure above collects and works on the accumulation from each cell. It now forwards to different elements. There are separate algorithms and attitudes based on the transaction. Artificial Neural Networks do not have accumulation aggregation problems in other professional systems. It gains experience by training sample data from old periods and begins to learn. It is necessary for the selected values to represent the ties desired to be learned without any problems.[19][20] Table 2 shows, results of comparison between model outputs and real world data. To predict wind speed and solar radiation based on ANN Modelling, error analyses and success ratio of the model have been presented in Table 2.

**Table 2.** Results of artificial neural network model

| **Comparison Model Results and Observation** | **Winter** | **Spring** | **Summer** | **Autumn** |
|---|---|---|---|---|
| **R, Wind speed** | 0.63 | 0.62 | 0.72 | 0.48 |
| **R, Solar Radiation** | 0.92 | 0.97 | 0.98 | 0.90 |
| **Absolute Error**<br><br>**Wind Speed** | 0.077 | 0.093 | 0.079 | 0.094 |
| **MSE**<br><br>**Wind Speed** | 0.010 | 0.044 | 0.010 | 0.016 |
| **RMSE**<br><br>**Wind Speed** | 0.100 | 0.129 | 0.101 | 0.127 |

| | | | | |
|---|---|---|---|---|
| **NRMS**<br><br>**Wind Speed** | 0.152 | 0.166 | 0.167 | 0.215 |
| **Absolute Error**<br><br>**Solar Radiation** | 0.036 | 0.032 | 0.033 | 0.035 |
| **MSE**<br><br>**Solar Radiation** | 0.004 | 0.002 | 0.003 | 0.004 |
| **RMSE**<br><br>**Solar Radiation** | 0.065 | 0.053 | 0.056 | 0.869 |
| **NRMS**<br><br>**Solar Radiation** | 0.063 | 0.063 | 0.060 | 0.085 |

# 4. CONCLUSION

Energy is the process of producing the possibilities in nature to meet the needs of people. In this thesis, the Kadıköy-Göztepe Region and its vicinity, which was selected as a pilot, were at and the wind intensity and solar energy potential for the region were area wisped and solar radiation were analysed estimated by using Artificial Neural Networks (ANN) and MATLAB programs. Wind speed (km/h) and solar radiation (W/m$^2$) speed were estimated seasonally. Parameters and data for the estimations of wind and solar energy potential in the sample region were obtained at Kadıköy - Göztepe Meteorology station. In order to estimate wind speed and solar radiation, 2m air temperature ($^o$C), 5 cm above ground temperature ($^o$C), solar radiation (W/m$^2$) and wind speed (km/h) parameters were selected as 10-minute averages. These parameters were normalized and processed.

The model was created with the help of the MATLAB program. With the help of the ANN model, the wind speed and solar radiation statistics, which will create input data for both wind and solar energy potential studies, were obtained by using the back propagation artificial neural network.

As a result of the model, it was determined that the highest wind energy potential is observed in summer (June, July, and August). The correlation coefficient between the observed and predicted values by ANN in this season is r=0.72, and it was determined that there is a significant relationship at $\alpha<0.01$ confidence level. The lowest success ratio in the estimation of wind speed values was obtained in the autumn season (September, October and November). The correlation coefficient between the observed and  estimated values by ANN in autumn is r=0.48, and it was concluded that there was a significant relationship at the $\alpha<0.10$ confidence level.

In the summer season (in June, July, August) solar radiation, accordingly, the highest performance was achieved in the estimation of solar radiation energy potential. The correlation coefficient between the values observed and estimated by ANN in this season was r=0.98, and a significant relationship was defined with $\alpha<0.01$ confidence level. The season in which wind speed and related wind energy potential are estimated with the lowest success ratio was determined in autumn (September, October, and November). The correlation coefficient between the values observed and estimated by ANN in this season is r==0.90, and it was concluded that there is a significant relationship at the $\alpha<0.01$ confidence level.

In the model study conducted for the study area, it was determined that the solar energy estimations were more successful than the wind energy estimations. Based on the outputs of the paper, it can be emphasized that the applied ANN model will make a significant contribution on to the energy estimation studies of both wind and solar hybrid systems with a confidence level of 0.05. This contribution can be obtained at most in the summer season.

The model improvement study for the wind energy potential in the region for the autumn season can be selected the next research topic. The results of the paper are primarily important at Turkey's wind-solar hybrid energy sector, determining new energy resources and strategies, (agriculture, irrigation, lightening, heating/cooling systems, traffic signalling, transportation, etc.,) due to its environmentally friendly structure. It is expected that it will contribute to the development of new technologies in many areas.

Based on these outputs, new research would be directed towards analyses of the performance of other models at different seasons.

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Research Article

# NEW THREE-PASS PROTOCOL FOR TIME-DEPENDENT INFORMATION

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***ABSTRACT***

*In this paper, a new encryption method based on statistical mechanics is proposed, which enables transmitting information without transmitting the encryption key after sending the information, and also makes it possible to determine its own transformation for each information cell. For these purposes, solutions of the Schrödinger equation (Lieb - Liniger Model) and a hierarchy of quantum kinetic BBGKY equations with the delta function potential are used.*

***Keywords***: Lieb-Liniger model, BBGKY hierarchy of quantum kinetic equations, tree-pass protocol, cryptography

## 1. INTRODUCTION

One of the most urgent problems of our time is the security of information transfer. This can be seen even from the fact how much spam we receive every day by email. It is known that Advanced Encryption Standard [1], which is the basis of western information encryption, is based on such chaotic actions as permutation of cells, columns and matrix rows, which are the conversion of plaintext to cipher text. These actions are random in nature and therefore do not provide complete confidentiality of information. Complete closeness of information can be provided if each information cell is closed using its own transformation. Such a complete set of transformations can be obtained by solving the equations for a function of N variables, where N is the number of cells. As known, there are very few exactly solvable equations for functions of N variables. One of the most reliable is the Lieb-Liniger Model for describing the system of bosons interacting by means of delta-function potentials. This problem was first solved by Lieb and Liniger [2] and is known in the scientific literature as the Lieb-Liniger Model. Another vulnerable point leading to the loss of information security is the process of the encryption key transmitting after sending encrypted information from the sender (Alice) to the recipient (Bob). This vulnerability can be eliminated if Alice and Bob have their own encryption keys.

Researchers drew attention to the problem of having their own encryption keys long before the development of modern information technologies. Back in the early 30s of the twentieth century, an attempt to play poker at a distance between Professor Niels Boh'r with his son, Heisenberg and other colleagues was unsuccessful, and a problem arose for the players to have their own encryption keys. Only in the 80s of the 20th century, Adi Shamir [3] indicated a way to solve this problem. His method of solving the problem is often called a three-step protocol (Fig.1). It consists of the following steps. Alice encrypts the information with her encryption key and sends it to Bob. Bob encrypts the received information with his own encryption key and returns the information now under the two encryption keys back to Alice. Alice, having received this information, decrypts it with her decryption key and sends the information now under one encryption key back to Bob. Information is now under one encryption key with Bob. Bob, having received this information from Alice, decrypts it with his decryption key. Now the information is without an encryption key and Bob can get acquainted with the information that Alice wanted him to transfer. This problem can be formulated as follows:

$$(D_B(D_A(E_B(E_A P)))) = (D_B(D_A(E_A(E_B P)))) = (D_B(E_B P)) = P,$$

where $E_A$ , $E_B$ the encryption keys of Alice and Bob, respectively, and $D_A$ , $D_B$ the decryption keys of Alice and Bob, respectively.

The encryption keys have the property

$$E_B E_A = E_A E_B$$

that is, the matrices of keys $E_A,\ E_B$ should be commutative. In this paper, we show the possibility of using expressions defined based on the Lieb-Liniger work as commutative Alice and Bob encryption keys for transmit-
ting information based on a three-step protocol. It is shown that to determine the amount of time-dependent information, one can use the solution of the Bogolyubov-Born-Green-Kirkwood-Yvon (BBKGY) hierarchy of quantum kinetic equations, when the equilibrium density matrix is determined through the Bethe ansatz [7].

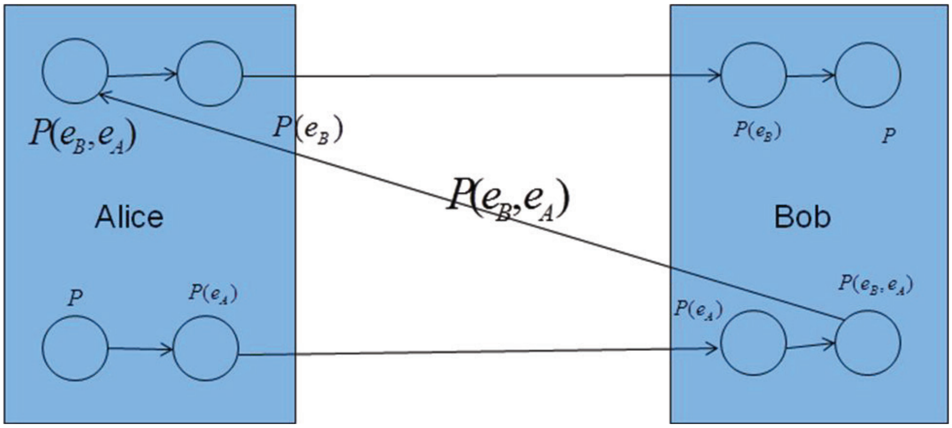


Fig. 1.
Here $P(e_A)=E_A P,\ P(e_B,e_A)=E_B(E_A P),\ P(e_B)=E_B P.$

## 11. BETHE ANSATZ FOR BOSE GAS

Following [3], consider the solution of the time independent Schrödinger equation for s particles interacting with the potential in the form of a delta function

$$\delta(x-x_0)=\begin{cases}\infty, if\ x=x_0\\ 0, if\ x\neq x_0\end{cases}$$

in one-dimensional space $\mathbb{R}$ :

$$-\frac{\hbar^2}{2m}\sum_{i=1}^{s}\Delta\psi(x_1,\dots x_s)+2c\sum_{1\leq i<j\leq s}\delta(|\,x_i-x_j\,|)\psi(x_1,\dots x_s)=E\psi(x_1,\dots x_s)$$

where the constant $c\geq 0$ and $2c$ is the amplitude of the delta function, $m=1$ - mass of boson, $\hbar=1$ - Plank constant, $\Delta$ -Laplasian, the domain of the problem is defined in $\mathbb{R}$ : all $0\leq x_i\leq L$ and the wave function $\psi$ satisfies the periodicity condition in all variables. In [3], it was proved that defining a solution $\psi$ in $\mathbb{R}$ is equivalent to defining a solution to the equation

$$-\sum_{i=1}^{s}\Delta_{x_i}\psi=E\psi, \tag{1}$$

ith the boundary condition

$$(\frac{\partial\psi}{\partial x_j}-\frac{\partial\psi}{\partial x_i})|_{x_j=x_{i+0}}-(\frac{\partial\psi}{\partial x_j}-\frac{\partial\psi}{\partial x_i})|_{x_j=x_{i-0}}=2c\psi|_{x_j=x_i}$$

for $\psi$ in the domain $\mathbb{R}_1: 0<x_1<x_2<....<x_s<L$ and the initial periodicity condition is equivalent to the periodicity conditions in

$$\psi(0,x_1,....,x_s)=\psi(x_1,....,x_s,L), \tag{2}$$

$$\frac{\partial\psi(x,x_2,....,x_s)}{\partial x}|_{x=0}=\frac{\partial\psi(x_2,....,x_s,x)}{\partial x}|_{x=L}. \tag{3}$$

Using equation (1) and conditions (2)-(3) we can determine the solution of equation (1) in the form of the Bethe ansatz [3], [4]-[7]:

$$\psi(x_1,...,x_s)=\sum_P a(Per.)Per.\exp(i\sum_{i=1}^{s}k_ix_i) \tag{4}$$

in the region $\mathbb{R}_1$ with eigenvalue $E_s=\sum_{i=1}^{s}k_i^{\,2}$ where the summation is performed over all permutations $Per.$

of the numbers $\{k\}=k_1,...k_s$ and $a(Per.)$ is a certain coefficient depending on $Per.$ :

$$a(Q)=-a(Per.)\exp(i\theta_{i,j}),$$

where $\theta_{i,j}=\theta(k_i-k_j)$ , $\theta(r)=-2\arctan(r/c)$ and when $r$ is a real value and $-\pi\le\theta(r)\le\pi$. For the case $s=2$ , one can find [3], [4] – [7]:

$$a_{1,2}(k_1,k_2)e^{i(k_1x_1+k_2x_2)}+a_{2,1}(k_1,k_2)e^{i(k_2x_1+k_1x_2)}$$

and

$$ik_2a_{1,2}+ik_1a_{2,1}-ik_1a_{1,2}-ik_2a_{2,1}=c(a_{1,2}+a_{2,1}),\qquad a_{2,1}=-\frac{c-(k_2-k_1)}{c+(k_2-k_1)}a_{1,2.}\ .$$

If we choose $a_{1,2}=e^{i(k_1x_1+k_2x_2)}$ one gets

$$e^{i(k_2x_1+k_1x_2)}=-\frac{c-(k_2-k_1)}{c+(k_2-k_1)}e^{i(k_1x_1+k_2x_2)}=-e^{i\theta_{2,1}}e^{i(k_1x_1+k_2x_2)}.$$

**111. THE BOGOLUBOV-BORN-GREEN-KIRKWOOD-YVON HIERARCHY OF QUANTUM KINETIC EQUATIONS AND ITS SOLUTION**

To consider the time-dependent information transfer, we use a chain of Bogoljubov-Born-Green-Kircwood-Yvon quantum kinetic equations in one-dimensional space; in this case, the BBGKY chain with the initial condition has the form [8],[9]:

$$\begin{aligned}&i\frac{\partial\rho_s^{\,L}(x_1,...,x_s;x'_1,...,x'_s,t)}{\partial t}=[H_s^{\,L},\rho_s^{\,L}](x_1,...,x_s;x'_1,...,x'_s,t)+\\&\frac{N}{L}(1-\frac{s}{N})Tr_{x_{s+1}}\sum_{1\le i\le s}(\phi_{i,s+1}(|x_i-x_{s+1}|)-\phi_{i,s+1}(|x'_i-x_{s+1}|)\times\\&\rho_{s+1}^{\,L}(x_1,...,x_s,x_{s+1};x'_1,...,x'_s,x_{s+1},t),\end{aligned} \tag{5}$$

with the initial date

$$\rho_s^{\,L}(x_1,...,x_s;x'_1,...,x'_s,t)|_{t=0}=\rho_s^{\,L}(x_1,...,x_s;x'_1,...,x'_s,0)$$

which has the form

$$i\frac{\partial\rho_s^{\,L}(x_1,...,x_s;x'_1,...,x'_s,t)}{\partial t}=[H_s^{\,L},\rho_s^{\,L}](x_1,...,x_s;x'_1,...,x'_s,t)+$$
$$\frac{2cN}{L}(1-\frac{s}{N})Tr_{x_{s+1}}\sum_{1\leq i\leq s}(\delta(|x_i-x_{s+1}|)-\delta(|x'_i-x_{s+1}|)\times$$
$$\rho_{s+1}^{\,L}(x_1,...,x_s,x_{s+1};x'_1,...,x'_s,x_{s+1},t),$$

for $1\leq s<N$ and

$$i\frac{\partial\rho_s^{\,L}(x_1,...,x_s;x'_1,...,x'_s,t)}{\partial t}=[H_s^{\,L},\rho_s^{\,L}](x_1,...,x_s;x'_1,...,x'_s,t)$$

for $s=N$ .

In Eq. (5), ρ is the density matrix, $x_i$ gives the position of i-th particle in the 1-dimensional space, i=1,2,…,s, $t$ is the time, $m=1$ is the particle mass, $\hbar=1$ is the Planck constant, N is the number of particles in the domain under consideration L (here we consider a system of bosons in the one-dimensional region $L$ , where $\Lambda=L^3$ with volume $V=|\Lambda=L^3|$), [ , ] denotes the Poisson bracket and H is the Hamiltonian of a system of particles, interacting with a potential in the form of a delta function δ :

$$H=-\sum_{i=1}^{N}\frac{\partial^2}{\partial x_i^2}+\sum_{i<j}\delta(x_i-x_j)$$

Here

$$\rho_s^{\,L}(t,x_1,...,x_s;x'_1,...,x'_s)=\sum_i^s\psi_i(t,x_1,...,x_s)\psi^*_i(t,x'_1,...,x'_s).$$

The reduced statistical operator of s particles is $\rho_s^{\,L}(x_1,...,x_s;x'_1,...,x'_s)$ when $s>s_0$ , $s_0$ - is a finite value

and the norm is determined as

$$\left|\rho^L\right|_1=\sum_{s=0}^{\infty}\left|\rho_s^L\right|_1,$$

and

$$\left|\rho_s^L\right|_1=\sup\sum_{1\leq i\leq\infty}\left|\rho_s^L\psi_s^i,\varphi_s^i\right|.$$

The upper bound is taken over all orthonormal systems of finite, twice differentiable functions with compact carrier $\{\psi_i^s\}$ and $\{\varphi_i^s\}$ in $\mathcal{L}_2{}^s(L)$ , $s\geq1$ and $|\rho_0^{\,L}|_1=|\rho_0^{\,L}|$.

Introducing the operator

$$(\Omega(L)\rho_s^{\,L})(x_1,...,x_s;x'_1,...,x'_s)=\frac{N}{L}(1-\frac{s}{N})\int_L\sum_i\rho_{s+1}^{\,L}(x_1,...,x_s,x_{s+1};x'_1,...,x'_s,x_{s+1})\times$$
$$g_i^1(x_{s+1})g_i^1(x_{s+1})dx_{s+1},$$

where $g_i^1(x_{s+1)})$ is the complete system of orthogonal vectors in the one-particle space $\mathcal{L}_2(L)$ and using the semigroup method, based on Stone's theorem in the space under consideration, we can determine the unique solution to the BBGKY hierarchy of quantum kinetic equations in the form

$$U^L(T)\rho^L(x_1,...,x_s;x'_1,...,x'_s)=(e^{\Omega(L)}e^{-iH^L{}_s t}e^{-\Omega(L)}\rho e^{iH^L{}_s t})_s(x_1,...,x_s;x'_1,...,x'_s) \tag{6}$$

when $1\leq s<N$ and

$$U^L(t)\rho^L(x_1,....,x_s;x'_1,....,x'_s)=(e^{-iH^L{}_s t}\rho e^{iH^L{}_s t})(x_1,....,x_s;x'_1,....,x'_s), \tag{7}$$

when $s=N$. Here $E_s{}^L=\sum_i^s k^2{}_i$ $0<x_1<...<x_s<L,$ and $0<x'_1<.....<x'_s<L.$

$$\rho_s{}^L(x_1,...,x_s;x'_1,...,x'_s)=\sum_i^s\psi_i(x_1,...,x_s)\psi^*{}_i(x'_1,...,x'_s),$$

where $\psi(x_1,...,x_s)$ Bethe ansatz .

Since the operator $U(t)$ is a unitary operator, then

$$\rho_s{}^L(t,x_1,...,x_s;x'_1,...,x'_s)=\rho_s{}^L(x_1,...,x_s;x'_1,...,x'_s).$$

Therefore

$$\psi(t,x_1,...,x_s)=\psi(x_1,...,x_s),$$

and the tranfer of both stationary information and time-dependent information can be described in terms of the Bethe ansatz..

For formulas (6) and (7), one can determine the von Neumann entropy (amount of information) using the formula: $S=Tr\rho_s{}^L Ln\rho_s{}^L$ , where $Ln$ is the natural matrix logarithm.

## 1V. APPLICATION OF BETHE ANSATZ IN INFORMATION TECHNOLOGY

Consider [7] how the last equation can be used for a three-step transmission of information. Let Alice encrypt information $P=e^{i(k_1x_1+k_2x_2+k_3x_3+k_4x_4)}=e^{i(k_0x_1+k_1x_2+k_1x_3+k_0x_4)}$ using encryption key $E_A=e^{i\theta_{(1+0+0+0),4}}e^{i\theta_{(0+0+1+0),3}}e^{i\theta_{(0+0+0+1),2}}e^{i\theta_{(0+1+0+0),1}}$

in binary and send the encrypted information to Bob:

$$E_AP=e^{i\theta_{(1+0+0+0),4}}e^{i\theta_{(0+0+1+0),3}}e^{i\theta_{(0+0+0+1),2}}e^{i\theta_{(0+1+0+0),1}}e^{i(k_0x_1+k_1x_2+k_1x_3+k_0x_4)}=e^{i(k_1x_1+k_0x_2+k_1x_3+k_0x_4)}.$$

Having received this information, Bob encrypts with his key $E_B=e^{i\theta_{(1+0+0+1),4}}e^{i\theta_{(0+0+1+0),3}}e^{i\theta_{(0+1+0+1),2}}e^{i\theta_{(1+1+0+0),1}}$ and sends the double-encrypted information back to Alice:

$$E_BE_AP=e^{i\theta_{(1+0+0+1),4}}e^{i\theta_{(0+0+1+0),3}}e^{i\theta_{(0+1+0+1),2}}e^{i\theta_{(1+1+0+0),1}}e^{i(k_1x_1+k_0x_2+k_1x_3+k_0x_4)}=e^{i(k_1x_1+k_0x_2+k_1x_3+k_1x_4)}.$$

Having received the last information from Bob, Alice decrypts it using her key $D_A=e^{i\theta_{(0+1+0+0),4}}e^{i\theta_{(0+0+1+0)1,3}}e^{i\theta_{(1+0+0+0),2}}e^{i\theta_{(0+0+0+1),1}}$

$$D_AE_BE_AP=e^{i\theta_{(0+1+0+0),4}}e^{i\theta_{(0+0+1+0)1,3}}e^{i\theta_{(1+0+0+0),2}}e^{i\theta_{(0+0+0+1),1}}e^{i(k_1x_1+k_0x_2+k_1x_3+k_1x_4)}=e^{i(k_1x_1+k_1x_2+k_1x_3+k_0x_4)}$$

and sends it back to Bob. Now the information is encrypted with only one key of Bob, and Bob, having received this information, decrypts it with his decryption key : $D_B=e^{i\theta_{(0+0+0+1),4}}e^{i\theta_{(0+0+1+0),3}}e^{i\theta_{(0+1+0+1),2}}e^{i\theta_{(1+1+0+0),1}}$:

$$D_B(D_A(E_B(E_AP)))=e^{-i\theta_{(0+0+0+1),4}}e^{-i\theta_{(0+0+1+0),3}}e^{-i\theta_{(0+1+0+1),2}}e^{-i\theta_{(1+1+0+0),1}}e^{i(k_1x_1+k_1x_2+k_1x_3+k_0x_4)}=$$
$$e^{i(k_0x_1+k_1x_2+k_1x_3+k_0x_4)}=P.$$

The last information is the same as Alice wanted to send Bob.

By expanding encryption keys $E_A$ , $E_B$ and decryption keys $D_A$ , $D_B$ in a matrix form, one can verify that the encryption process and $E_A$, $E_B$, $D_A$. $D_B$ are equivalent to the process of encryption and decryption in matrix form:

$$e^{i(k_2x_1+k_1x_2)}=\sum_{i=0}^{\infty}\frac{i^n}{n!}(\{x_1 \quad x_2\}T\begin{Bmatrix}k_1\\k_2\end{Bmatrix})^n,\ \text{where } T=\begin{Bmatrix}0 & 1\\1 & 0\end{Bmatrix}:$$

**Example:**

$$E_A=\begin{bmatrix}0&1&0&0\\0&0&0&1\\0&0&1&0\\1&0&0&0\end{bmatrix} \qquad E_B=\begin{bmatrix}1&1&0&0\\0&1&0&1\\0&0&1&0\\1&0&0&1\end{bmatrix}$$

$$D_A=\begin{bmatrix}0&0&0&1\\1&0&0&0\\0&0&1&0\\0&1&0&0\end{bmatrix} \qquad D_B=\begin{bmatrix}1&1&0&0\\0&1&0&1\\0&0&1&0\\0&0&0&1\end{bmatrix}.$$

Matrices $E_A$ and $E_B$ are commutative:

$$E_A\times E_B=\begin{bmatrix}0&1&0&0\\0&0&0&1\\0&0&1&0\\1&0&0&0\end{bmatrix}\times\begin{bmatrix}1&1&0&0\\0&1&0&1\\0&0&1&0\\1&0&0&1\end{bmatrix}=E_B\times E_A=\begin{bmatrix}1&1&0&0\\0&1&0&1\\0&0&1&0\\1&0&0&1\end{bmatrix}\times\begin{bmatrix}0&1&0&0\\0&0&0&1\\0&0&1&0\\1&0&0&0\end{bmatrix}=$$

$$=\begin{bmatrix}0&1&0&1\\1&0&0&1\\0&0&1&0\\1&1&0&0\end{bmatrix}.$$

For binary case:

$$\text{Let } P=\begin{bmatrix}0\\1\\1\\0\end{bmatrix} \qquad E_1P=\begin{bmatrix}0&1&0&0\\0&0&0&1\\0&0&1&0\\1&0&0&0\end{bmatrix}\times\begin{bmatrix}0\\1\\1\\0\end{bmatrix}=\begin{bmatrix}1\\0\\1\\0\end{bmatrix}$$

$$E_2E_1P=\begin{bmatrix}1&1&0&0\\0&1&0&1\\0&0&1&0\\1&0&0&1\end{bmatrix}\times\begin{bmatrix}1\\0\\1\\0\end{bmatrix}=\begin{bmatrix}1\\0\\1\\1\end{bmatrix}\qquad D_1E_2E_1P=\begin{bmatrix}0&0&0&1\\1&0&0&0\\0&0&1&0\\0&1&0&0\end{bmatrix}\times\begin{bmatrix}1\\0\\1\\1\end{bmatrix}=\begin{bmatrix}1\\1\\1\\0\end{bmatrix}$$

$$D_2D_1E_2E_1P=\begin{bmatrix}1&1&0&0\\0&1&0&1\\0&0&1&0\\0&0&0&1\end{bmatrix}\times\begin{bmatrix}1\\1\\1\\0\end{bmatrix}=\begin{bmatrix}0\\1\\1\\0\end{bmatrix}=P$$

## V. CONCLUSION

In this paper, a new encryption method based on statistical mechanics is put forward, which allows transmitting information without transmitting the encryption key after sending the information, as well as determining its own transformation for each information cell. To this end, solutions of the Schrödinger equation (within Lieb-Liniger Model) and the hierarchy of the BBGKY quantum kinetic equations with a delta-function potential are used.

**Advantages** of the proposed algorithm and information transfer method:

(1) The presence of a total conversion system ensures full diffusion of bits at each stage of the information transfer in a three-stage protocol.

(2) The algorithm is economically efficient since good diffusion enables using a small number of bits. If in modern programs five cells are required to express letters, then in the proposed approach a letter can beexpressed using one cell.

(3) It is possible to establish a zero correlation between plaintext and encrypted texts, which is condition for perfect encryption.

(4) The proposed method eliminates the encryption keys transfer between partners, which is the most dangerous part of information transfer.

(5) The proposed approach will make it possibleto run programs written using the suggested technique both on current computers and on quantum computers.

(6) The proposed approach will enable boson propagation programming, including bosons of light, in one-dimensional space and in time.

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*Research Article*

# STUDY FOR SYSTEM IDENTIFICATION OF THE BOX CULVERT MODEL WITH AUTOMATED ARTIFICIAL INTELLIGENCE*

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***ABSTRACT***

*Structures are exposed to dynamic effects, but the responses of structures to these effects are mainly calculated with theoretical assumptions. The inadequacy of these theoretical approaches is accepted and criticized by all civil engineering circles. This situation brings with it the search for new solutions. In recent years, experimental methods have become widespread in calculating the responses of structures to dynamic effects. The system identification method is one of these methods. With the system identification method, the mathematical model of the structure system can be obtained. Thus, dynamic parameter estimations give more realistic results. Today, the use of artificial intelligence-neural network is widespread in every field, as well as in the field of system identification. For this reason, in this study, the system identification of the box culvert model was made with the automated artificial intelligence method. As a result of this study, the system identification of box culvert model was made with a success rate of approximately close to one hundred percent. The automated artificial intelligence can provide a very fast andtrue to solve problem in system identification studies. In the light of this study, it is seen that automated artificial intelligence can be used on system identification method in civil engineering field.*

***Keywords:*** *System Identification, Automated Artificial Intelligence, Mathematical Model, Neural Network, Box Culvert*

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## 1.INTRODUCTION

Today, studies and developments about earthquake resistance of structures are very popular. There are many old and new methods used especially when determining the earthquake performance of structures. The methods used in the past century and the beginning of the 21st century have been replaced by newer and more reliable methods. The old methods are generally theoretical and based on some assumptions. The new methods, on the other hand, include more experimental methods and the data represent more real situations. System identification method is one of these methods. System identification (SI) is a modeling process for an unknown system based on a set of input outputs and is used in various engineering fields [1], [2]. With system identification, a mathematical model of the system is created. Effects and reactions on the created model are determined realistically by the mathematical model. In determining the earthquake performance, it is of great importance to obtain the mathematical model of the structure or model correctly. It is known that it is possible to obtain correct earthquake performance only with the correct mathematical model.

The system identification method also includes various improvements. Especially today, the use of artificial intelligence is seen in many areas. In the field of system identification, its use in obtaining parameters and processing data is seen in current academic studies. The authors have many studies [3-19] on system identification and artificial neural network given in the sources. It has been clearly seen that the limits of automated artificial intelligence are pushed by covering various models in these academic studies. Based on all this information, the very up-to-date automated artificial intelligence method was used on system identification in this study. It was decided to choose the box culvert model as the model. Also, it is aimed to interpret the data obtained in the study by sharing it clearly in the results section.

## 2.AUTOMATED ARTIFICIAL INTELLIGENCE

Automated Artificial Intelligence (AutoAI) is a variant of automated machine learning (AutoML) technology that goes beyond model construction to automate the whole life cycle of a machine learning model. It automates the process of creating predictive machine learning models by preparing data for training, determining the optimum model type for the given data, and selecting the features or columns of data, that best support the problem the model is solving. Finally, as it develops and ranks model-candidate pipelines, automation checks a number of tweaking possibilities to achieve the optimal result. AutoAI defines the requirements and tools to perform such a model selection and tuning work, and provides guidance on the process of building the best set of tools and systems for automating the entire machine learning development lifecycle. This work builds on the automating transformations approach, which enables domain-specific machine learning models to be rapidly developed and deployed into production using specialized, domain-specific or multi-function cloud and on-premises platforms. AutoAI reduces time-to-value and accelerates time-to-insight through. Multi-disciplinary AI architectures that support model building, model tuning, model testing, and model deployment. The concept of multidisciplinary AI has been demonstrated in a variety of domains including the auto industry. AutoAI also proposes a powerful mechanism for specifying and sharing data representation and information about model components. This makes it possible for an enterprise to compose a machine learning system consisting of relatively small chunks of domain-specific machine learning code, which can be optimized to solve very specific problems. Model selection and tuning capabilities, which allow users to share components of their machine learning system, such as parameters, features, and ML models. Model selection and tuning tools can be distributed across a large company, while still allowing consistent tuning and analytics across these components. For example, users can share common ML model architectures (such as neural networks) for predicting goods purchased or miles driven, but can then also share the tuning rules and the data models necessary for identifying the best parameters for this model. In other words, users can build their own machine learning system, but can also freely share their data, architectures, and tuning rules. The new models can then be deployed into production on top of the shared components of the system.

## 3.MODEL SELECTION

One of the primary challenges for enterprise machine learning models is the selection of data and model architecture. Automated machine learning provides the power to quickly optimize machine learning models for problems that are specific to an organization. AutoAI enables the automated selection and prioritization of a large number of machine learning models for a particular domain, and presents users with a list of models that best fit the requirements of the problem, and may be used to solve that problem. It also provides a set of model options that include existing and new machine learning models, with descriptions and links to public descriptions of those models, to be used to explore their performance. Finally, it highlights metrics associated with each model to be selected, such as accuracy, precision, and predictive accuracy, and provides a visual model selection flow that allows users to rapidly select the best model. AutoAI also features other kinds of model selection and tuning workflows, including models that may need to be pre-trained and evaluated before a data-driven solution can be deployed to solve a problem, and models that may be unqualified by the domain experts that write the use cases, but are suitable for a particular problem and data set. By providing modeling capabilities for the selection of models and tuning of those models, AutoAI reduces the risk of failure in a very risky model development phase.

## 4.MODEL TUNING

The second primary challenge of most enterprises is tuning a machine learning model. AutoAI's predictive tuning, prediction quality and model quality metrics support a number of pre-built models, and allow users to use it to understand their model performance. AutoAI shows the signal-to-noise ratio of any model at any time, with a highly graphical and informative display, and it provides measurements for modeling quality and metrics for the predictive performance of a model. AutoAI enables users to see where there are performance issues, provide feedback for further tuning, and identify outliers that may need to be fixed. AutoAI can also provide the flexibility to use their own (in-house) models, which can then be used as is, or to apply them in a flexible way to the problem, and tune them based on the needs and the domain. For example, AutoAI supports a number of auto-tuning capabilities, including the ability to perform "average vs. max" regression, or use default features that are commonly seen in existing machine learning models, and the ability to specify a desired learning rate. Artificial intelligence can be complex, and so an enterprise can benefit from having multiple intelligent systems. AutoAI brings together different kinds of models for a specific problem, providing insights and tuning capabilities for those models that address the particular constraints of the domain. AutoAI is composed of four modules, each having an independent use case. AutoAI "Inception" has the model training module, "Training" provides data acquisition and storage, and the tuning module. AutoAI "Synapse" has the configuration and customization module, "Configure", and the data and model pipelines module, "Pipeline", which runs the "AutoAI Customizer". AutoAI "Layers" is the compute module, which allows users to upload or import their data and then run them through AutoAI. After the creation of AutoAI, data should be gathered. Data can be gathered using a variety of data sources. AutoAI is built to work with a wide variety of sources, including open source, commercial, and both structured and unstructured data. AutoAI creates, manages, and indexes the training data used to train the models, and provides the tools needed to make those models understandable, as well as providing visualizations of their performance. AutoAI's "AutoML Inception" and "Synapse" allow users to run and manage auto-tuning as well.

Automated artificial intelligence flowchart is given in figure 1.

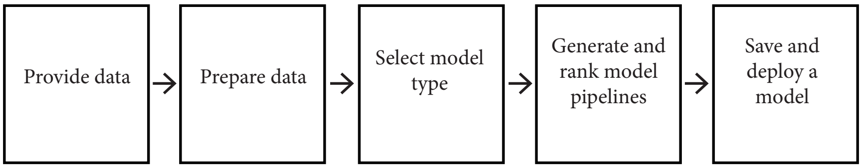


**Figure 1.** Automated artificial intelligence flowchart

AutoAI enables auto-tuning of predictive models for a variety of enterprise use cases, including predictive maintenance of industrial systems and industrial machines. In addition to predictive maintenance of industrial machines, AutoAI can also be used to provide predictions for these machines, help people understand what these machines are doing, and to guide the way people work. For example, AutoAI can be used to show machine performance based on operating data or system parameters, or the expected output of a predictive algorithm for a certain part of a machine. AutoAI can also be used to provide automated tuning of predictive models, or to perform remediation on models after they have been implemented. AutoAI can be used to perform comprehensive risk modeling and analysis of a company's critical assets, including whether or not to use maintenance, or what level of maintenance is appropriate, or what areas of the asset needs to be replaced. AutoAI can also be used to conduct predictive analytics on operational data or on big data in order to better identify trends, make informed business decisions, and improve operations.

## 5.EXAMPLE USE CASES

Automation is not limited to traditional infrastructure industry, and the implementation of technology is changing the field of construction. Even though the application of technologies in the field of civil engineering is relatively simple and there are various benefits associated with this, there are some constraints that need to be overcome before these technologies can reach their full potential. For example, there are a lot of challenges associated with the deployment of such technologies, such as the absence of specialized tools and equipment, high cost, human errors, lack of resources and other regulatory issues. The same problems also face organizations in many other industries when it comes to the adoption of AI, such as the lack of skills, the risk associated with the data lack of integration across existing IT systems, challenges associated with new regulatory requirements and shortage of investment. For the best results, companies should have the right skills and technical environment in place to successfully implement AI and machine learning technology. AI and machine learning technology are coming in as a disruptive force to all organizations, and these technologies can enhance an organization's existing abilities.

-AutoAI can be used to train "general-purpose" ML models in a range of areas, including

-Predictive maintenance of critical assets, including industrial machines

-Reporting on the historical or present status of assets or systems

-Updating/revisiting the current assets or systems

-Automating the ability to identify when new or existing assets are at risk

-Predicting when systems will fail

-Saving and using historical or current asset records in a database

-Monitoring asset health

-Metadata management

AutoAI is able to do this because it has pre-trained ML models, which can be shared or customized in order to meet a particular application's requirements. Predictive analytics can be used to improve the quality of predictions in order to reduce or eliminate the need for analysts to be involved with the models at all, as well as to more accurately understand the model's prediction. In addition, since predictions tend to be more accurate when they are derived from and monitored against the past, modeling the past is a very important part of what AutoAI can do. Additionally, since AutoAI automatically figures out which predictions are most important or useful, analysts can then be able to focus on the models that matter most to them. In some cases, auto-tuning a model is used to create a model that is better suited to what a person needs to do. For example, an analyst might want to automate work processes related to maintenance for industrial machines. Such analysis can take a lot of time and lead to incorrect conclusions, if the analyst does not have the training and experience to understand the machine, its history, and the maintenance process. When auto-tuning is used, it reduces the need for the analyst to do the analysis, and can savetime for everyone. Additional capabilities of AutoAI include the ability to automatically map models to the constraints and interfaces of a system, and the ability to cleanse the data that has been used to train the model.

The self-learning capability of AutoAI makes it possible to make changes to the underlying model without the need for an external ML library. AutoAI can be used as an end-to-end ML pipeline, from data preparation to ML training to ML inference to model selection and model deployment. Self-tuning means AutoAI can adapt to changes in the input data to improve its prediction accuracy. AutoAI can also adapt over time as it learns the unique characteristics of each data set, making it an effective tool for analytics and for getting a step closer to true self-learning. AutoAI can be trained with real-world data. It can use this training data to create a predictive model that is tailored to a particular situation. This is what makes AutoAI an effective tool for ML in industrial or engineering. Because it is run locally, AutoAI can be used in order to predict problems that are specific to a user's factory or production facility. For example, a machine might have had a recent part failure, which makes it more likely to fail in the future. AutoAI can be trained to identify the parts that are more likely to fail, which could be based on the location where the part failed or if it was kept in the machine for a long period of time. This type of deep understanding of a problem allows AutoAI to automatically pick out what parts to analyze, which can dramatically improve predictive accuracy. AutoAI has the capability to automatically create an artificial neural network based on the input data. This means a user does not need to create and train a model. Instead, AutoAI performs the task automatically. It learns the conditions of each input data set and makes its prediction with the information gatheredfrom each input data set. This is what makes it a very effective tool for analyzing large amounts of data. Automation with AutoAI not only eliminates the need for an analyst to perform the modeling work, but also makes it more productive. Instead of wasting time that could have been spent using the time to make more important analyses, AutoAI can speed up workflows and reduce the number of mistakes made. Application in civil engineering and forensic engineering has found AutoAI to be a useful tool for its workflows. Data scientists, statisticians, and industrial engineers have reported success using AutoAI for applications related to fleet management, agriculture, and machine learning. In addition, several sales organizations have been using AutoAI to automate their pipeline data preparation, so they do not have to waste time manually reviewing each data set they receive.

## 6.DESCRIPTION OF BOX CULVERT MODEL

The box culvert model is designed entirely of concrete. The concrete used is C30-TS500. Artificial intelligence engineering can be used in infrastructure. Box culvert attract attention in this regard. They are exposed not only to dynamic effects, but also to the effects of the fluids in them. For this reason, the box culvert model was chosen in this study. However, in this study, there is no fluid in the box culvert during the measurements. The reason for this is to keep the data volume small by using the simpler model instead of complex systems. Together with the examination of the complex models, it is planned to examine the fluid-filled culverts in this way in the future. The cross section of the model box culvert is square shaped. The height of the model box is 3 meters. The width of the model box culvert is 3 meters. The wall thickness of the model box culvert is 0.25 meters. The length of the box culvert model is 6 meters. The dimensions of the box culvert model are also given in figure 2. The three-dimensional view of the box culvert model is given in figure 3.

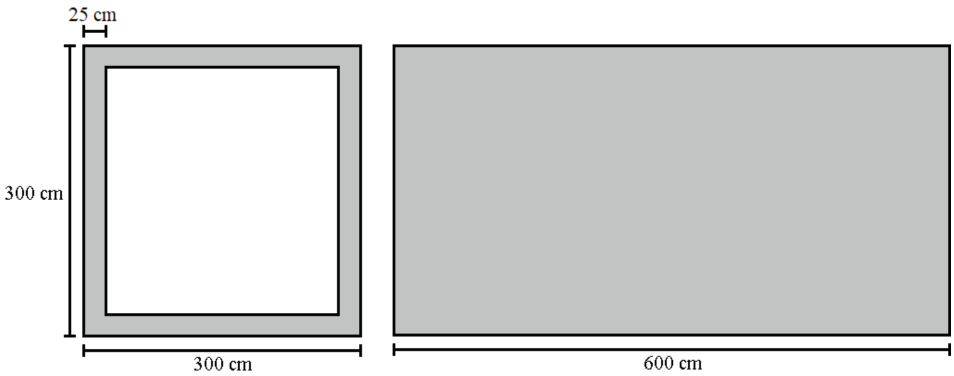


**Figure 2.** The dimensions of the box culvert model

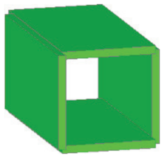

**Figure 3.** 3D view of the box culvert model

## 7.RESULTS AND DISCUSSION

MATLAB 2018b software program [20] automated artificial intelligence toolbox was used to obtain all the results. Obtained results are shared as figures.

In the figure 4 it shows the training progress of the neural network.

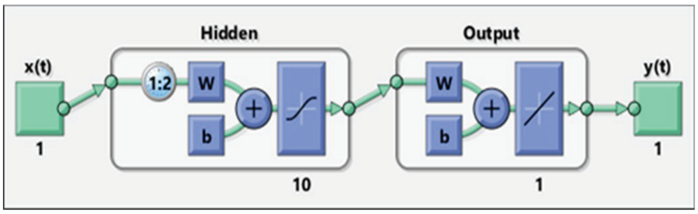


**Figure 4.** Neural network

process The input used in the study are given in figure 5.

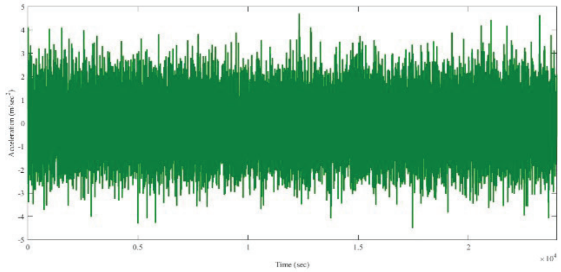


**Figure 5.** Input

The output used in the study are given in figure 6.

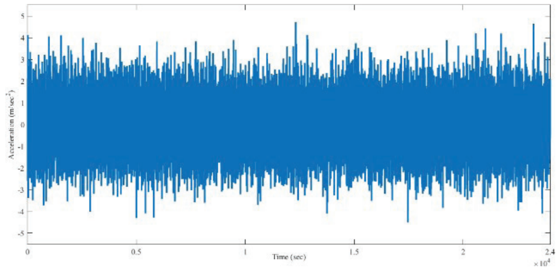


**Figure 6.** Output

The box culvert model's frequency obtained is given in figure 7.

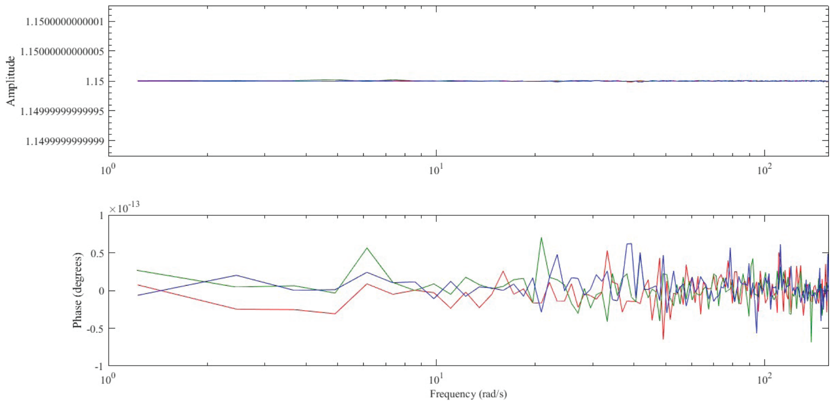


**Figure 7.** Frequency

The box culvert model's periodogram obtained is given in figure 8.

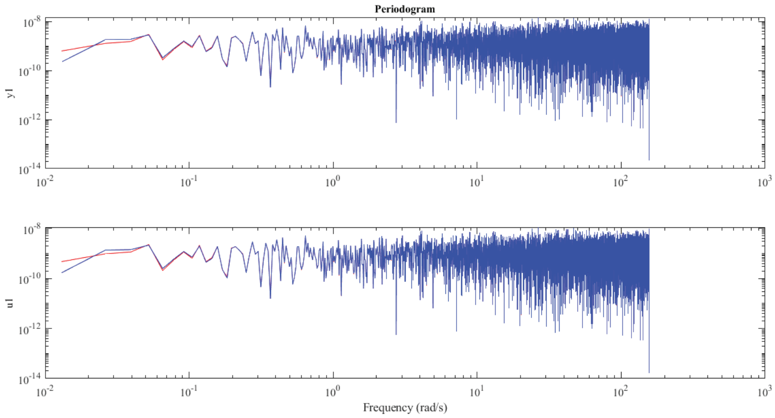


**Figure 8.** Periodogram

The box culvert model's poles and zeros obtained is given in figure 9.

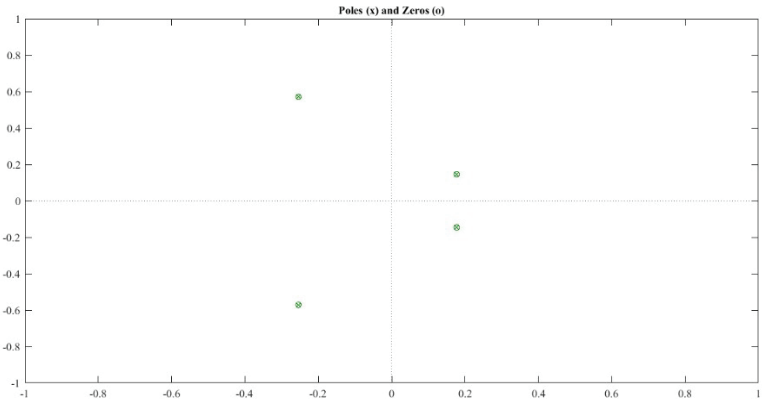


**Figure 9.** Poles and zeros

The box culvert model's residuals obtained is given in figure 10.

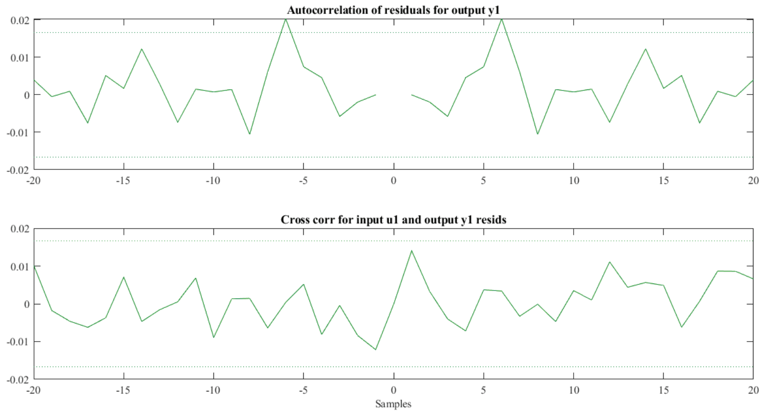


**Figure 10.** Residuals

The box culvert model's error histogram obtained is given in figure 11.

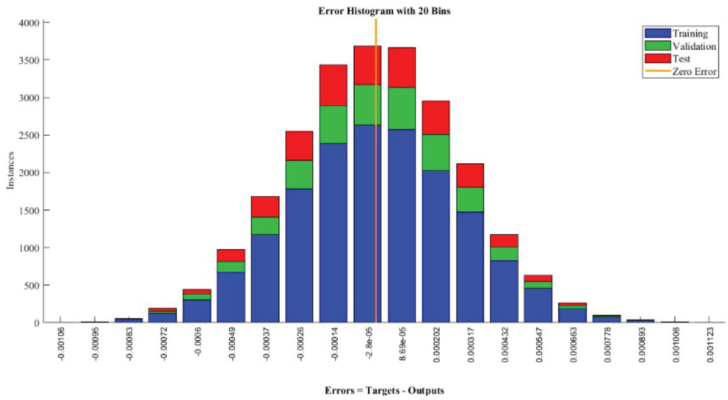


**Figure 11.** Error histogram

The box culvert model's response of output element obtained is given in figure 12.

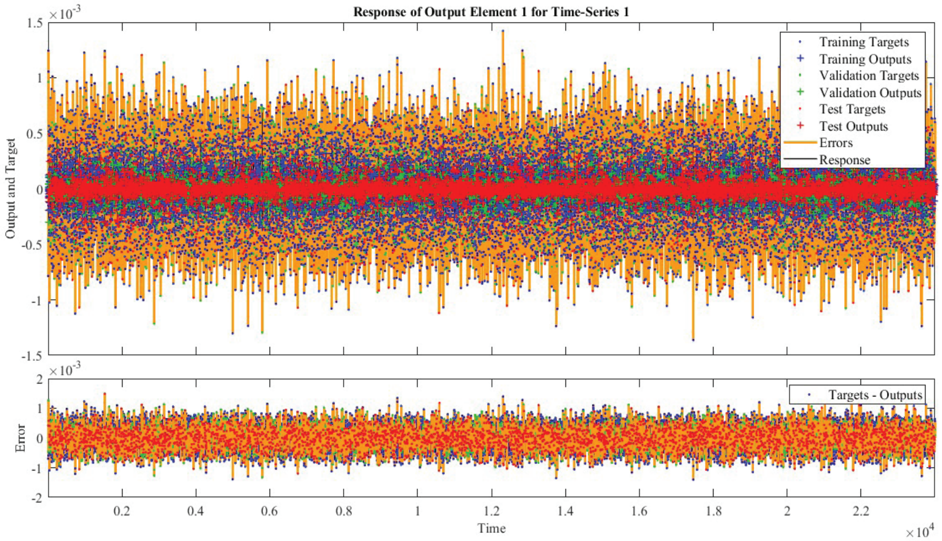


**Figure 12.** Response of output element

## 8.CONCLUSION

As a result of this study, the following graphics belonging to the box culvert model were obtained.

- The box culvert model's frequency

- The box culvert model's periodogram

- The box culvert model's poles and zeros

- The box culvert model's residuals

- The box culvert model's error histogram

- And the most important; The box culvert model's response of output

When all the findings are examined, it is seen that the automated artificial intelligence method makes very successful predictions on system identification. Thus, it is predicted that the accuracy and reliability of the data to be used in the future will increase. In addition, the processing speed and practicality of the automated artificial intelligence method attracted a lot of attention. In the light of all this information, the automated artificial intelligence application on a square shaped box culvert model was tested in terms of accuracy, practicality and utility, and successful results were clearly obtained. It is thought to be particularly successful in early warning systems against dynamic loads. In addition, it is recommended in the field of data processing and evaluation in civil engineering on the other word system identification.

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# NUMERICAL STUDY OF NATURAL CONVECTION IN A FINNED RECTANGULAR ENCLOSURE HEATED FROM BELOW AND COOLED FROM ABOVE *1

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***ABSTRACT***

*Laminar natural convection in an air filled enclosures heated from below and cooled from above is studied numerically. Fins are attached to the hot wall in order to study the effect of fins number on the heat transfer. The working fluid media is air with Prandtl number of 0.71 and Rayleigh number ranging from $10^4$ to $10^6$. The coupled equations of continuity; momentum and energy are solved by a finite volume method. The SIMPLE algorithm is used to solve iteratively the pressure velocities coupling. The numerical investigations in this analysis are made over a wide range of parameters, cavity aspect ratio, Rayleigh number and number of fins. The effect of these parameters was evaluated. Results are presented graphically in the form of streamlines, isotherms and also with temperature profiles and average Nusselt numbers. The heat transfer increases with the increase of the aspect ratio and Rayleigh number and decreases with the increase of fins number.*

***Keywords**: Natural convection; Rayleigh-Bénard convection; steady regime; fin; Rayleigh Number;Nusselt Number.*

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# 1.INTRODUCTION

Studies of natural convection in confined cavities have for several years been the subject of several studies, because of its involvement in many natural phenomena and industrial applications. The Rayleigh Bénard convectioncan be encountered in many physical applications as the rooms heating in buildings or the cooling of electronic components.

Natural convection heat transfer in cavities has been a subject for various experimental and numerical studies found in the literature [1–3]. Numerical simulation of two-dimensional Rayleigh–Bénard convection in an enclosure is investigated by Ouertatani et al [4], a Benchmark solution are proposed for Rayleigh numbers ranging from $10^3$ to $10^6$. Some streamlines and isotherms are presented to analyze the natural convection flow patterns set up by the buoyancy force.

Also, a two-dimensional steady-state simulation of laminar natural convection in square enclosures with differentially heated horizontal walls with the bottom wall at higher temperature have been conducted by Turan et al [5] for yield-stress fluids obeying the Bingham model. Heat and momentum transport are investigated for Rayleigh number in the range $10^3$–$10^5$ and a Prandtl number range of 0.1–100. The mean Nusselt number is found to increase with increasing values of Rayleigh number for both Newtonian and Bingham fluids.

Natural convection heat transfer inside a vertical rectangular enclosure with four two-dimensional discrete flush-mounted heaters is investigated numerically and experimentally by Ho et al [6] to expose the influence of aspectratio of the enclosure. Their numerical results reveal that the increase of the aspect ratio leads to substantial degradation of convective dissipation from the discrete heaters.

Different Modes of Rayleigh–Bénard Instability in Two- and Three-Dimensional Rectangular Enclosures are described by Gelfgat et al [7], The results of the parametric calculations are presented as neutral curves showing the dependence of the critical Rayleigh number on the aspect ratio of the cavity.

Raji et al [8] showed numerical results of natural convection within an air-filled square cavity with its horizontal walls submitted to different heating models. The temperature of the bottom horizontal surface (hot temperature) is maintained constant, while that of the opposite surface (cold temperature) is varied sinusoidally with time. The remaining vertical walls are considered adiabatic. In comparison with the constant heating conditions, it isfound that the variable cooling temperature could lead to an extreme change in the flow structure and the corresponding heat transfer. This leads to a resonance phenomenon characterized by an important increase in heat transfer by about 46.1% compared to the case of a constant cold temperature boundary condition.

Steady natural convection in an enclosure heated from below and symmetrically cooled from the sides is studied numerically by Ganzarolli et al [9], using a stream function-vorticity formulation. The Rayleigh number based on the cavity height is varied from $10^3$ to $10^7$. Values of 0.7 and 7.0 for the Prandtl number are considered.The aspect ratio (length to height of the enclosure) is varied from 1 to 9. Boundary conditions are uniform wall temperature and uniform heat flux. Numerical values of the Nusselt number as a function of the Rayleigh number are reported, and the Prandtl number is found to have little influence on the Nusselt number. Further, Laminar and turbulent Rayleigh–Benard flows in a perfectly conducting cubical cavity were numerically simulated by Pallares et al[10] , Complete numerical simulations of laminar flows were conducted in the range of Rayleigh numbers $7*10^3< Ra < 10^5$. . The large-eddy simulation (LES) technique was used for the simulations at two high Rayleigh numbers ($Ra = 10^6$ and $10^8$).

Natural convection in enclosure with discrete isothermal heating from below is studied by Goutamet al[11]. They found that the effect of enclosure aspect ratio on the average Nusselt number of the discrete heaters tends to improve with the increase of the Grashof number.

Abdul Rasih et al [12] studied Natural Convection in Polar Enclosure Heated from Below and Cooled from Above, Simulations are performed for several values of both the length in radial direction with angle direction ratio of the enclosure, and the Rayleigh number based on the angle of enclosure in the range of $10^2$ to $10^6$. Their results show that the increase in both aspect ratio and Rayleigh number gives an effect on flow configuration of the enclosure. Otherwise, Mirabedin et al [13] performed a two-dimensional numerical simulation to study natural convection in circular enclosures filled with water considering different central angles. They showed that decreasingcentral angle of the cavity increases averaged Nusselt number in a cavity heated from below.

In addition to the above-mentioned previous studies, comprehensive investigations of the natural convection flow in Rayleigh Bénard enclosures with fins on the hot wall have been reported in the currentliterature. The effects of the number, material and position of the fins on the natural convection flow in the cavity have been remunerated much attention. In most of these studies, the thickness of the fin is considered to be sufficiently small in comparison with the length fin.

Zilic et al [14] examined the augmentation of classic Rayleigh-Bénard convection by the addition of periodically-spaced fins attached to the heated, lower plate. The respective impacts of the fin size, the fin spacing and the thermal conductivity of the fin material are observed through numerical simulations, they found that for veryshort fins, an enhancement of heat transfer is possible for the range of conditions examined.

Rayleigh-Bénard convection driven by the temperature difference of horizontal top and bottom surfaces ofa finned square cavity filled with liquid gallium for Pr=0.024, is studied numerically by Selamet et al [15] for Ra=$10^5$ and 3×105. Steady or unsteady, they illustrated the cellular flow structures and temperature patterns along with evolution of heat transfer rates (Nusselt number). The effect of fin length and placement on flow regime and heat transfer is established, they concluded that Short fins play a stabilizing role for Ra=$3\times10^5$.

Also, natural convection in a square cavity with a thin partition for linearly heated side walls is analyzed by Sathiyamoorthy et al [16]. The purpose of their paper is to optimize the heat transfer rate in square cavity by attaching fin at the bottom wall. They found that attaching fin reduces heat transfer rate inthe cavity.

Pathak et al [17] studied numerically natural Convection in Rectangular Enclosure with Heated Finned Base; the enclosure is heated from bottom wall and is cooled from the opposite top wall while the other walls of the enclosure are assumed to be adiabatic. They observed that Nu increases with increasing the number of fins until it reaches a maximum at certain fin spacing and with further increasing the number of fins, Nu starts to decrease. The heat transfer rate also increases with increasing the Rayleigh number.

Karki et al [18] made a Comparative study on air, water and nanofluids based Rayleigh–Benard natural convection using lattice Boltzmann method. One part of study shows the deviation in onset of critical Rayleigh number for air is 1.58%. The other part indicates dimensionless heat transfer, fluid flow and total irreversibility decrease with the increase in volume fraction of nanoparticles in the base fluid. However, Haragus et al [19] studieda bifurcation of symmetric domain walls for the Rayleigh–Bénard convection problem; they prove the existence of domain walls for the Bénard–Rayleigh convection problem. Their approach relies upon a spatial dynamics formulation of the hydrodynamic problem, a center manifold reduction, and a normal forms analysis of an eight-dimensional reduced system.

The purpose of this study is to simulate the natural convection in a Rayleigh-Benard heated cavity with finson the hot wall and different number of fins. The side walls are assumed to be adiabatic and the flat top and bottom walls are considered as differentially heated. The thermal and flow behavior and heat transfer characteristics have been studied for various Rayleigh number and aspect ratio. The working fluid media is air with Prandtl number of and Rayleigh number ranging from $10^3$ to $10^6$.

## 2.ANALYSIS AND MODELING

The numerical model considered is shown schematically in Figure 1. It is a rectangular cavity filled with airwith a fins placed on the bottom wall, surface heated from below in two dimensions with a side equal to L which represents the length of the cavity and a height H, aspect ratio is A = L / H=2 , the height (h) of the fin is H/3.The Prandtl number is equal to 0.71. The two vertical walls are maintained adiabatic, while the horizontal walls are kept isothermal (the lower hot wall Th, and the upper cold wall, Tc). The numerical study was carried out with the CFD code [24] using a two-dimensional model and the Boussinesq approximation for air. The investigation concerns cases with Rayleigh numbers ranging from $10^4$ to $10^6$, the effect of the fins is observed.

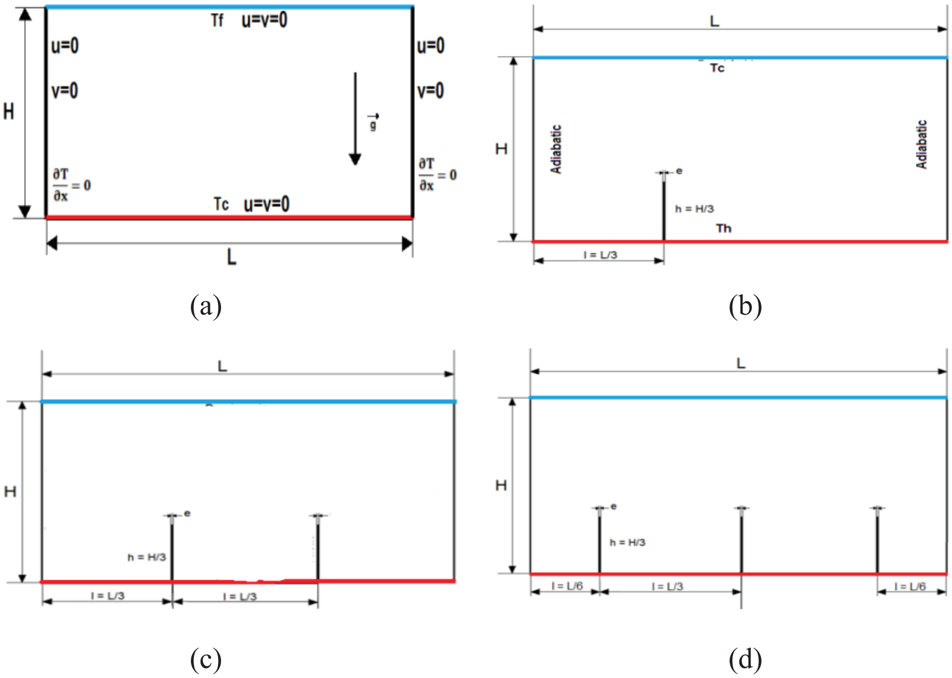



**Figure 1.** physical domain and boundary conditions (a) without fin, (b) 1 fin, (c) 2 fins, (d) 3fins.

The natural convection in the cavity as depicted in Figure 1 is described by the differential equations expressing conservation of mass, momentum and energy. The Boussinesq approximation is implemented for thefluid properties to relate density changes to temperature change and to couple in this way the temperature field to theflow field. The governing equations for Rayleigh Bénard convection can be expressed as follows:

$$\frac{\partial U}{\partial X}+\frac{\partial V}{\partial Y}=0 \tag{1}$$

$$U\frac{\partial U}{\partial X}+V\frac{\partial U}{\partial Y}=-\frac{\partial P}{\partial X}+\Pr\left(\frac{\partial^2 U}{\partial X^2}+\frac{\partial^2 U}{\partial Y^2}\right) \tag{2}$$

$$U\frac{\partial V}{\partial X}+V\frac{\partial V}{\partial Y}=-\frac{\partial P}{\partial y}+\Pr\left(\frac{\partial^2 V}{\partial X^2}+\frac{\partial^2 V}{\partial Y^2}\right)+Ra.\Pr.\theta \tag{3}$$

$$U\frac{\partial \theta}{\partial X}+V\frac{\partial \theta}{\partial Y}=\left(\frac{\partial^2 \theta}{\partial X^2}+\frac{\partial^2 \theta}{\partial Y^2}\right) \tag{4}$$

$$Ra=\frac{g\beta L^3\Delta T}{\eta\alpha}\quad\text{and}\quad \Pr=\frac{\eta}{\rho} \tag{5}$$

$$X=\frac{x}{L},\quad Y=\frac{y}{L},\quad U=\frac{uL}{\alpha},\quad V=\frac{vL}{\alpha}$$

$$P=\frac{pL^2}{\rho\alpha^2},\quad \theta=\frac{T-T_0}{\Delta T},\quad \Delta T=T_h-T_0$$

The average Nusselt number is defined as follows:

$$Nu=-\int_0^x \left.\frac{\partial\theta}{\partial y}\right|_{y=0} dx \tag{6}$$

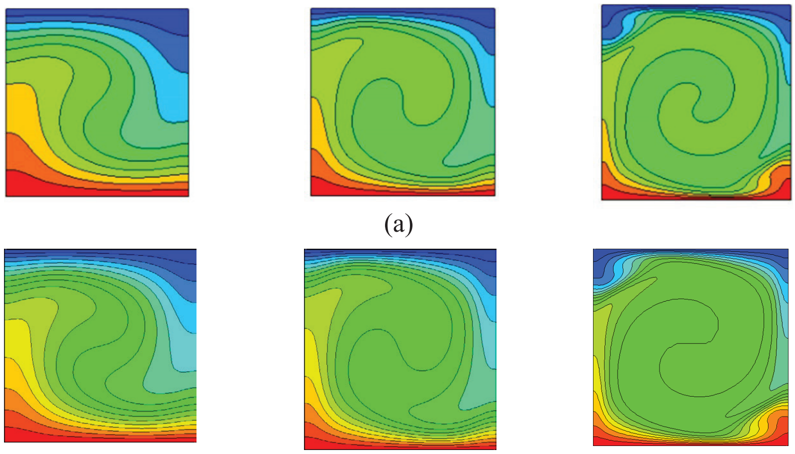
The boundary conditions are no slip for all walls and for energy equation; the horizontal walls have been maintained at differentially heated condition while the other walls are considered as adiabatic. The boundary conditions and the flow domain are shown in figure 2. It can be written mathematically as non-dimensional form:

| | | |
|---|---|---|
| Right surface | U=V=0, $\frac{\partial\theta}{\partial Y}=0$ | (7a) |
| Left surface | U=V=0, $\frac{\partial\theta}{\partial Y}=0$ | (7b) |
| Top surface | U=V=0, $\theta=-0.5$ | (7c) |
| Bottom surface | U=V=0, $\theta=0.5$ | (7d) |

# 3.NUMERICAL METHOD AND MODEL VALIDATION

The adimensional governing equations with their boundary conditions are solved using the finite volume method. The SIMPLE (semi-implicit method for pressure linked equations) algorithm is used to determine the pressure field, while the QUICK scheme is used to discretize the convection terms in the momentum and energy equations. The program was used to generate the grid of the simulated domain.

In order to verify the accuracy of the simulation results obtained with the CFD code, a validation was made, taking into account the numerical studies of Ouertatani et al [4]. The same boundary conditions were used: the fluid is air, of the case where the aspect ratio is 1, for different Rayleigh number, where the lower wall completely heated, the upper wall is cooled and the other walls are considered adiabatic.



(a)

(b)

Ra = $10^4$ Ra = $10^5$ Ra = $10^6$

**Figure 2.** Comparison of isotherm contours for different Rayleigh number and A = 1Ouertatani et al [4], (b) present result

**Table 1.** Comparison of mean Nusselt number for A=1 and different Grashof number

| Rayleigh number | Present study | [4] |
|---|---|---|
| $10^4$ | 2. 1463 | 2. 1581 |
| $10^5$ | 3.7303 | 3.9103 |
| $10^6$ | 6.5134 | 6.3092 |

For Rayleigh numbers from $10^4$ to $10^6$, the comparison of the isotherms with the numerical results of Ouertatani et al [4] (Figure 2) show an excellent agreement. This allows to validate our numerical simulation procedure. Also, a comparison of the averaged Nusselt numbers $Nu_m$ (Table 1), the results are in quite agreement with those of [4].

The grid system for the computational domain is created using structured quadrilateral cells. A grid independency test was carried out, four sets of grids 50×25, 100×50,200×100and 200×100were employed; the case with 200×100grids (Figure 3) was used for taking both the accuracy and convergence rate into account.

To choose the best mesh which allows to obtain the most exact results possible, we studied the influence of the size and the distribution of the nodes on the average Nusselt number (Figure 4) for Rayleigh number varies between $10^4$ to $10^6$ (Table.2).

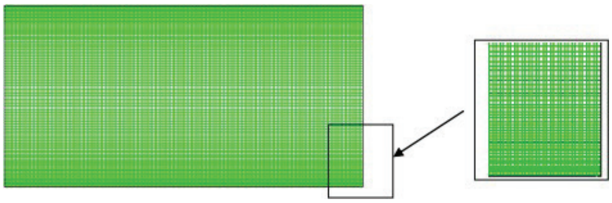


**Figure 3.** Grid Structure used in the computations(A=2)

**Table 2.** Mean Nusselt number for different grids and different Rayleigh number Ra

$Nu_m$

| Grid numbers in X-Y | $Ra=10^4$ | $Ra=10^5$ | $Ra=10^6$ |
|---|---|---|---|
| **50×25** | 2,2618 | 3,56918 | 6,14002 |
| **100×50** | 1,89941 | 3,5376 | 6,0982 |
| **200×100** | 1,5648 | 3,1832 | 6,0229 |
| **300×150** | 1,5734 | 3,185 | 6,0233 |

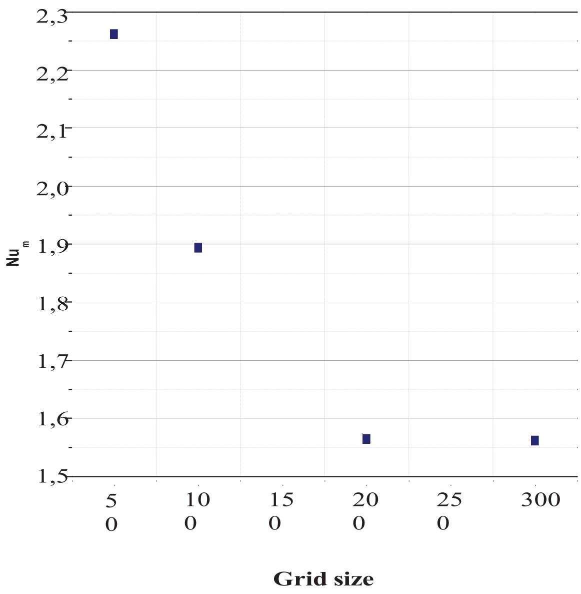



**Figure 4.** Variation of mean Nusselt for different grids and Rayleigh number Ra =$10^5$

## 4.RESULTS AND DISCUSSION

Figure 5 shows the streamlines for Rayleigh numbers Ra =$10^4$ to $10^6$. For Ra = $10^4$, the values of the stream function increase and the streamlines change to square rolls. For higher values of the Rayleigh number Ra = $10^5$ and Ra = $10^6$ the streamlines change to become transverse rolls. These rolls are still developing to become square rolls but with the narrowing of their centres. The increase in the Rayleigh number therefore reflects an intensification of natural convection.

The isotherms contours are shown in Figure 6 for different values of the Rayleigh number. For small Rayleigh, the isothermal lines are parallel to the two horizontal plates, the temperature distribution is simply decreasing from the hot plate to the cold plate; the heat transfer is essentially by conduction. These isothermal lines begin to change and deform slightly for Ra = $10^4$, this reflects a growing Rayleigh-Bénardconvection. Heat transfer is dominated by a convective regime. For high values of the Rayleigh number (Ra =

$10^5$ and Ra = $10^6$), the isothermal lines deform to become perpendicular to the plates in the central part and become horizontal in the vicinity of the plates. It is also noted that these lines are narrowing at the level of thesolid walls, which reflects a very intense transfer in these regions. The development of Rayleigh-Bénard's instability is clearly noted by the visible development of hot temperature plumes that attempt to brush a path upwards and therefore the cold particles move downwards.

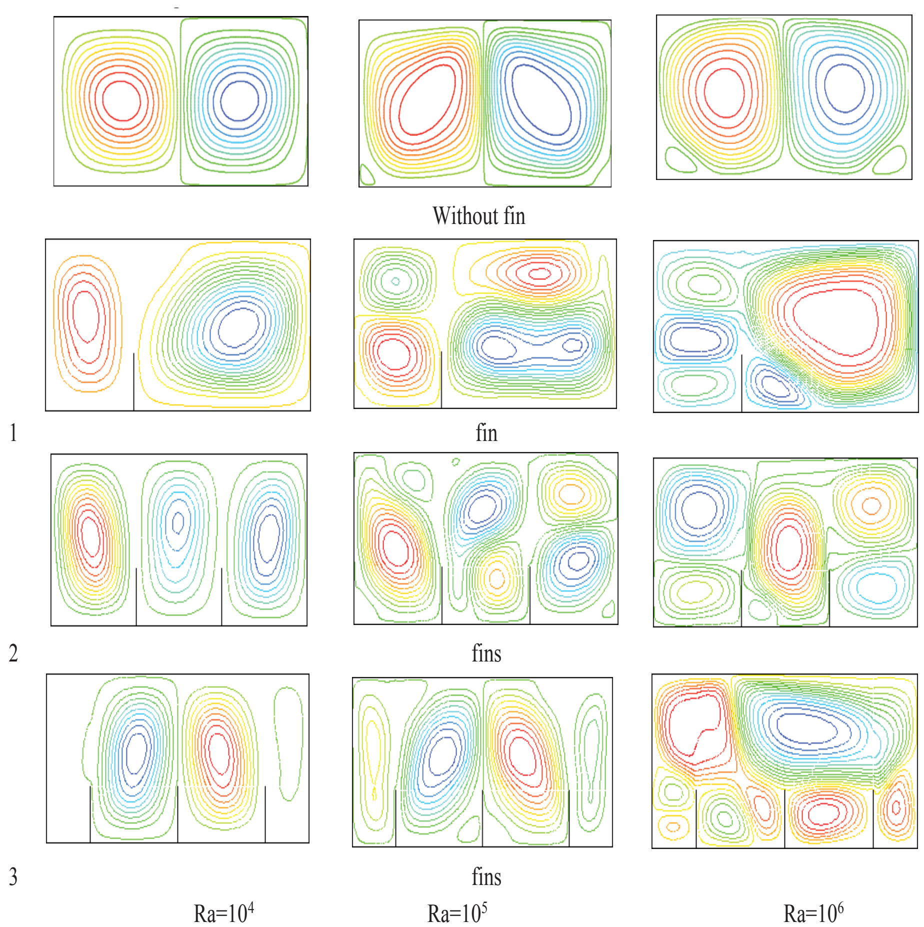



**Figure 5.** Streamlines for different Rayleigh number.

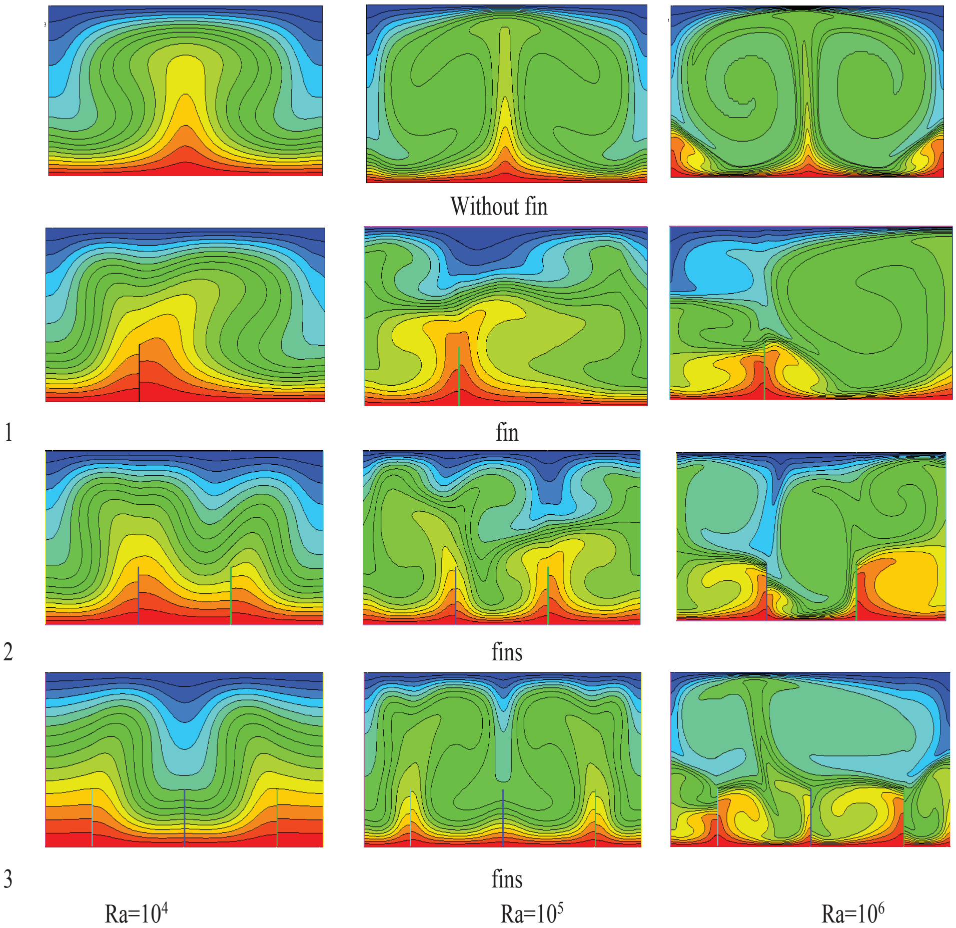



**Figure 6.** Isotherms contour for different Rayleigh number.

As shown in Figures 5 and 6, the number of the fins has a large impact on the characteristics of the temperature wave and streamlines. The variations of the characteristics of the isotherms are associated with the variations of fins number. The fin is an important parameter, when the number of fins increases the temperature alsoincreased.

Figure 7 shows the local Nusselt number distributions at the hot wall for different fins number and differentRayleigh number; it is observed that the addition of fins has an influence on the local Nusselt number and on theheat transfer. Because of the symmetry of boundary conditions, the center of the heated part becomes a zone of minimal heat flow since it is at a maximum temperature; this implies a minimal local Nusselt number (Figure 7 (a))

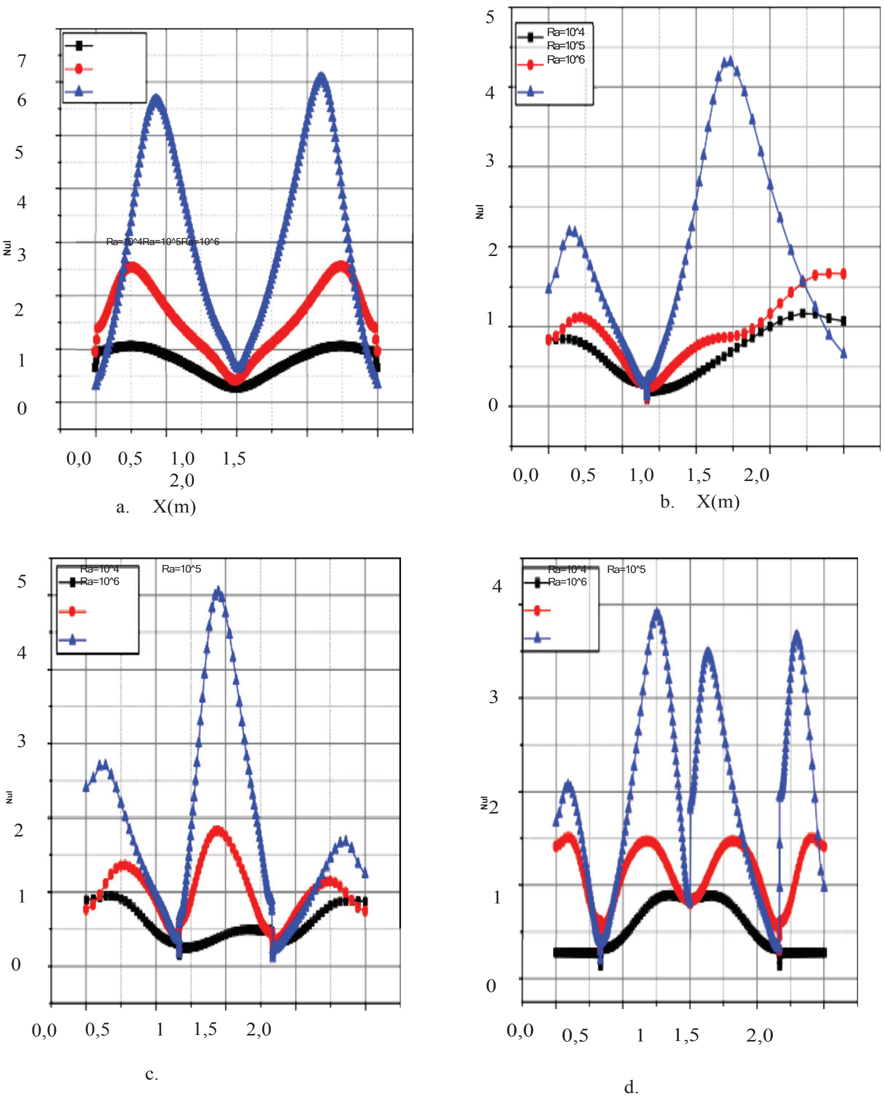



**Figure 7.** Local Nusselt number along the hot wall for different Rayleigh number and fins number. (a) Without fin, (b) 1 fin, (c) 2 fins, (d) 3 fins.

The distribution of the mean Nusselt number for different fins number is shown in Figure 8 for the Rayleigh number Ra = $10^5$. It is shown that the mean Nusselt number increases when the Rayleigh number is increased. It is clearly seen that there is an influence of fins number on the average Nusselt number; the trend of the curve decreases significantly with an increase in the fins number.

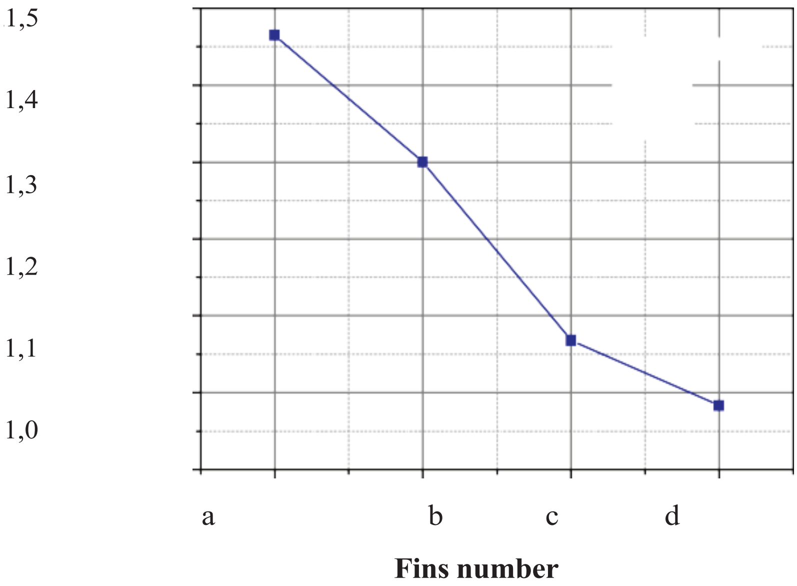



**Figure 8.** Mean Nusselt number along the hot wall versus fins number

The heat transfer through the finned hot wall is notably enhanced so the presence of fins on the hot wall shows a promising result for the enhancement of the heat transfer through a Rayleigh Bénard cavity. Thus, the mean Nusselt number is much smaller near the fins, although oscillatory downstream of the fins.

## 5.CONCLUSION

Laminar natural convection within air filled Rayleigh-Bénard enclosures which is heated from below and cooled from above is studied numerically. Fins are attached to the hot wall in order to study the effect of fins number on the heat transfer. The numerical investigations in this analysis are made over a wide range of parameters, Rayleigh number and number of fins. The effect of these parameters was evaluated. Results are presented graphically in the form of streamlines, isotherms and also with temperature profiles average Nusselt numbers and local Nusselt number. The heat transfer rate is found to decrease with an increase in the fins number, and increase with an increase of Rayleigh number.

The results obtained show that for a low Rayleigh number the dominance of the heat transfer mode is by conduction. Beyond this value, the convection dominates and appears more clearly for Ra = $10^5$. It has been concluded that the heat transfer rate increases with the increase of the Rayleigh number and decreases with the increase of fins number, which shows that natural convection is very sensitive to the variation of Rayleigh number and the number of fins.

## ACKNOWLEDGEMENT

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