CHAPTER ONE
INTRODUCTION

1-1Background

Indoor environmental conditions are important to the health, comfort and productivity of occupants. Accumulating evidence has shown that poor climate quality is related to increased Sick Building Syndrome (SBS) symptoms and decreased work performance (Seppanen and Fisk, 2006) [1]. Recent studies by Lan et al. (2011) [3] and Tsai et al. (2012) [2] reported that thermal discomfort and high indoor carbon dioxide concentrations increase SBS symptoms for office workers. Ventilation systems are therefore widely used to provide a good indoor environment with respect to thermal comfort and indoor air quality. By delivering a sufficient amount of outdoor cool fresh air into the room, excess heat and internally generated contaminant concentration levels can be removed and reduced. Natural ventilation appeared as an attractive strategy used in the past to provide an acceptable microclimate in the space being ventilated (Busch, 1992) [4], but it is limited to range of climates, microclimates, building types, etc. (Allocca et al., 2003) [5]. To enhance control of indoor climate, mechanical ventilation is desirable, which can be used for different types of buildings and offers more possibilities to regulate room air temperature, humidity, air speed and

At present, conventional mixing and displacement ventilation are still most widely used, though they have some disadvantages and limitations. To overcome the drawbacks of these systems while retaining the strengths they provide, Impinging Jet Ventilation (IJV) was proposed by Karimipanah and Awbi (2002) [9] to be used for space ventilation, cooling and heating. This system combines positive aspects of mixing and displacement ventilation and therefore has a promising application. (Huijuan Chen)[2014]. [10]

products being used indoors. In addition, inadequate ventilation rates sometimes generate poor distribution of indoor air flow, temperature and contaminant concentration in the occupied zone, which might consequently cause problems for the indoor environment (Chen and Glicksman, 2003) [7]. Moreover, in a modern society, people spend most of their time indoors where they perform the major activities of working and living. Combined this leads to an increasing dependency for the desired indoor environment of buildings on ventilation and air conditioning systems.

In today's office environment, computers and other heat generating devices are widely used, and these internal heat gains together with intense solar conditions can result in a high heat load in enclosures. This poses challenges for office ventilation.

Meanwhile, ventilation systems account for a large part of the total energy usage in the residential and service sector in Sweden (SEA, 2012) [8]. Sweden has set up national goals related to the European Union's climate and energy goals, and energy use in the building sector must be reduced by 20% by 2020 and 50% in residential and commercial buildings by 2050 compared

1-2 Air Distribution Systems

1-2-1 Local exhaust ventilation (LEV)

This method of ventilation is based on the base of restrain the contaminant at source before it spreads into the room air, [11], shown in Fig. (1-1). LEV exact is used, and its farm and flow parameter are most of this method of vent. [12].

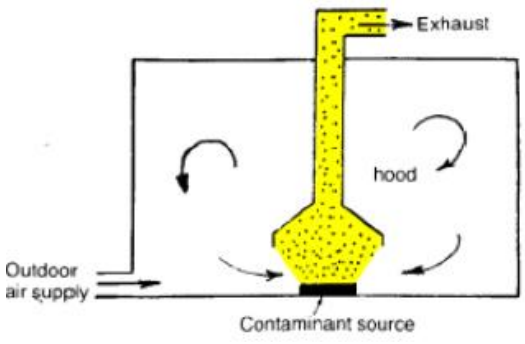


Fig. (1-1) concept of local exhaust ventilation system, [12]

1-2-2 Mixing ventilation system (MV)

The mix applicate is to diffusion the supply air into the space so that the thermal and ventilation contaminant concetrate are form in the enter space or in a specific area of the field (Halton, 2012).

In order to achieve a good mixing, air is supplied at a high momentum, because recirculation and good mixture with indoor air are necessary to reach acceptable efficiencies. Roughly speaking, this system tries to dilute pollutant concentrations with fresh air, as shown in Fig. (1-2). However, this configuration is usually less efficient than other air supply methods.

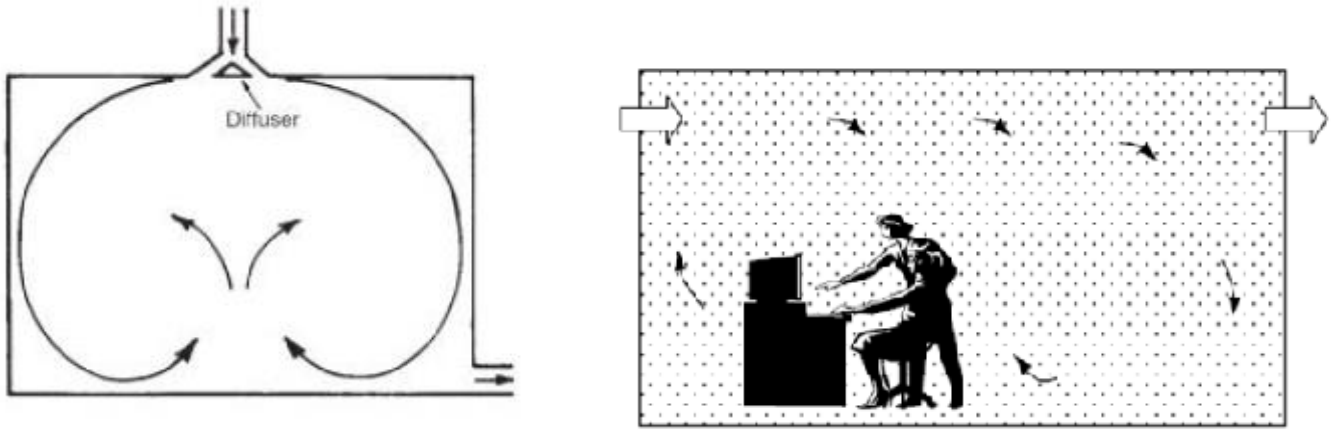
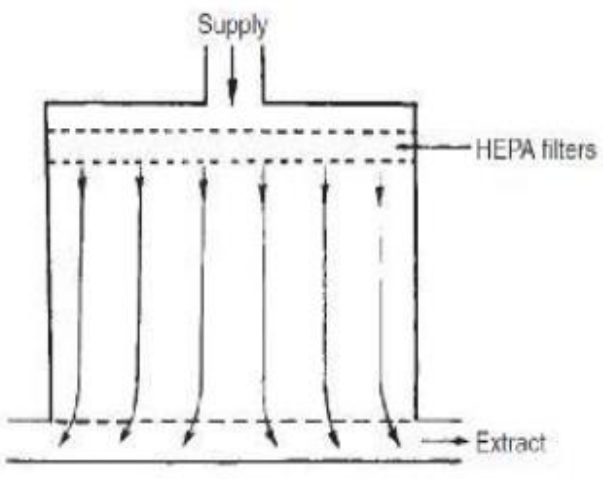


Fig. (1- 2) concept of mixing ventilation (Taghi Karimipanah. 2012)[13]

1-2-3 Piston ventilation (PV)

The kind of the simple kind of air distribution. Flow is a direct "flow of air in which indoor air people the room air of it. The room is cleaned continuously by outdoor diffusion air and results in many". Piston is used in cleaned room and operating and where high airflow rates, as shown in Fig. (1-3).



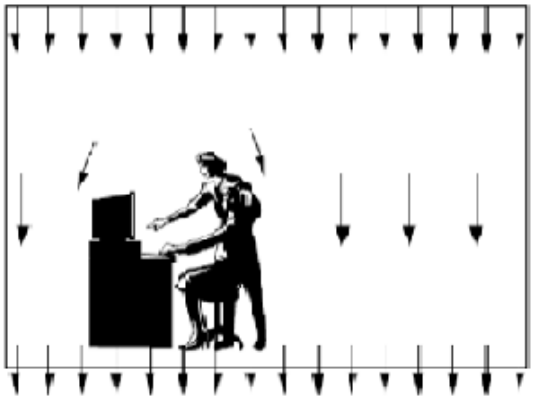


Fig. (1-3) concept of piston flow (Taghi Karimipanah. 2012) [13]

1-2-4 Displacement ventilation system (DV)

Displacement Ventilation system Fig.(1-4a&b) can be defined as room ventilation created by room air displacement, through delivering air at low level and velocity in a space at a low air temperature to be suitable for large spaces, such as concert halls and workshops,[6]. Simply, it may be defined as any airflow pattern where "old" air is displaced by "new" air, [14].

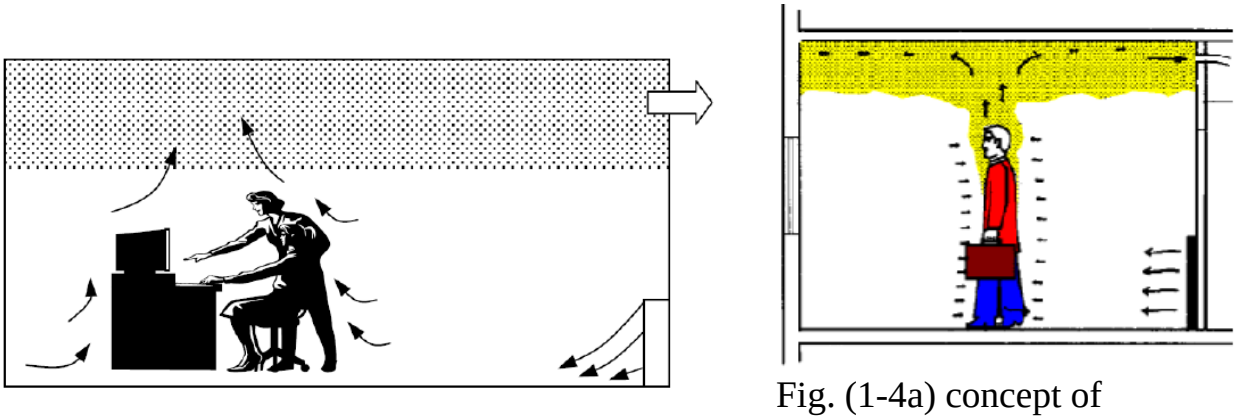


Fig. (1-4a) concept of displacement ventilation, (Taghi Karimipanah. 2012)[13]

1-2-5 Hybrid ventilation systems

This type of systems are being developed with the aim of combining both mixing and displacement ventilation system, and therefore be able to avoid their disadvantages and seize their advantages. In terms of flexibility, high

momentum ventilation systems are better that buoyancy based ventilation systems.

"A new method of air distribution known as the Air Queen (AQ) has been developed in Sweden", as shown in Fig. (1-5), "which is based on Impinging Jet Ventilation (IJV)", [17]. "This method is based on the principle of supplying a jet of air with high momentum downwards onto the floor". "As the jet impinges onto the floor it spreads over a large area causing the jet momentum to recede but still has a sufficient force to reach long distances", (T. Karimipanaha) [2001].[18]

The supply device is located a certain distance above the floor. This system combines some characteristics "of mixing and displacement ventilation". The most relevant are, (Karimipanah, Sandberg & Awbi, 2000):[19]

- "It supplies air at higher momentum than displacement ventilation systems, and lower momentum than mixing ventilation systems in some cases".
- "It is possible to achieve higher air exchange efficiency than in using mixing ventilation and more or less same as using displacement ventilation".
-"It offers possibility of jet entrainment as in mixing ventilation".
-"Air can be heated before entering into the room, in contrast to displacement ventilation. For that reason, this type of system has potential applications for heating and cooling rooms".
-"Number of particles in the air and allergic substances in the air are less than in traditional supply systems".

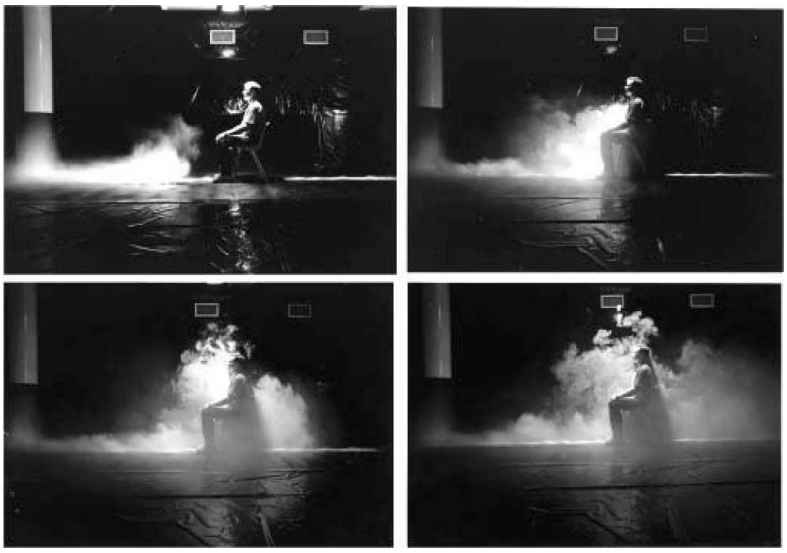


Fig. (1- 5) smoke visualization of impinging jet ventilation, (Taghi Karimipanah. 2012)[13]

This system can work with larger cooling loads than displacement flow and it can be used for heating purposes.

"Similar types of impinging jet supply devices (Air Queen) have been installed in different buildings, e.g. schools, offices, industrial buildings, etc." "The device is similar in looks to a duct and is mounted onto a wall. It supplies air downward to the floor and contaminated air is exhausted from ceiling level".

"Four applications of impinging jet ventilation in Sweden are shown in Fig. (1-6a&d)". "One of these represents an installation in a school, one in an office building and two in industrial buildings". "Fig. (1-6a) shows an installation of impinging jet supply in System 3R International, which was installed to replace displacement devices in a building where precision instruments tools are manufactured".

"When displacement ventilation was used there were many complains from the workers and after their replacement with impinging jet systems no compliment was reported". "Fig. (1-6b) shows IJV installed in a factory for heavy metal industry". "Fig. (1-6c) shows the application in a school and Fig.

(1-6d) is in an office in Stockholm". "Since installing the impinging Jet ventilation system in all these buildings no complains have yet been reported". "Another advantage of impinging jet ventilation is that the duct itself has a sound damping effect, which reduces aerodynamic noise at the supply terminal". .

a b

c d

"Fig. (1- 6) practical applications of impinging jet ventilation: (a) system 3R international factory (b) heavy metal industries (c) school (d) office", (T.Karimipanaha,)[2001] [18]

"The impingement of a turbulent jet on a flat plate (wall) has been widely studied with different configurations. In all early investigations, the prediction of the momentum flux follows the same procedure as in a classical boundary layer".

"The impinging jet is an interesting test case due to its different flow regions (i.e. the potential core region, the free jet region, the impinging or flow deflection region and the wall jet region)". "Some early and recent

investigators have also studied the free and impinging jet phenomena". "Beltaos and Rajaratnam [20] provided detailed results for the impingement region and enlarged the scope of the results which were available in the free jet and wall jet regions. Gutmark et al. [21] presented an experimental studyof the turbulent structure on the center-line of a two dimensional impinging jet".

"They pointed out that the impingement of the jet is not affected by the presence of the plate over 75% of the distance between the nozzle and the plate and also the turbulent properties of the jet change from their equilibrium level close to the impingement region". "The impinging jet is somewhat similar to a stagnation flow in which an infinite stream impinges on a finite body".

"The impinging jet configuration investigated "as shown in Fig. (1- 7(a&b)) "The flow field is divided into three regions, see also Ref. [20]: (i) a free jet region, (ii) the impingement region and (iii) the wall jet region". "There are also transitional zones between these regions".

"The numerical analysis and development of impinging flows have received large attention, not because of their simplicity, but due to the presence of different flow regions". "However, the result from the analysis may depend on the turbulence model used".

The plate when the mid line velocity begin to average from the free curve take at locations of end the free region and starting of the impinging area. The fig two see the effect [20]. (T.Karimipanaha[18]

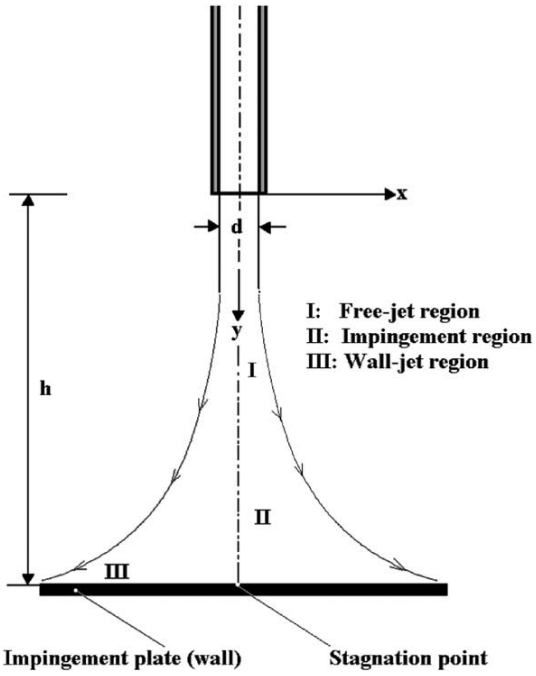


Fig. (1-7a) impinging jet configuration.

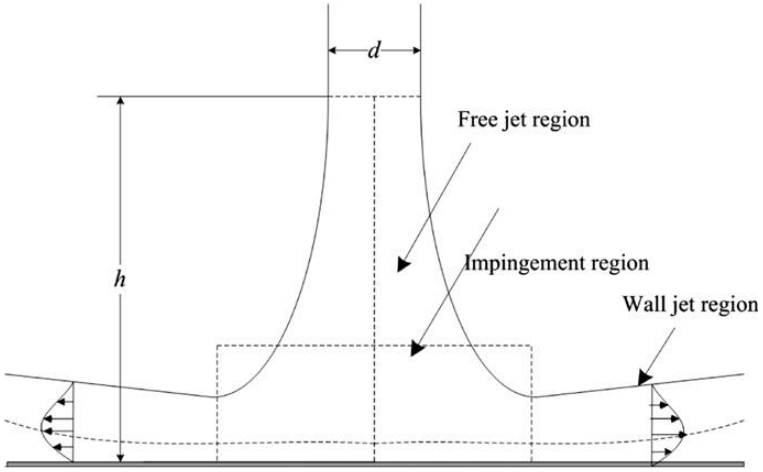


Fig. (1-7b) flow regions of an impinging jet, (Huijuan Chen)[2014][10]

1-4 Occupant Distribution

The effectiveness of an air distribution system in supplying indoor air to a ground is defined by air change effectiveness' or sometimes called 'air exchange efficiency. Another useful concept in the length of many the indoor air system remained in the ventilated space is the 'age of air'. On the other hand, the ability of the air distribution system of removing internally

produced pollutants is referred to as the ‘ventilation effectiveness’ or sometimes called the ‘ventilation efficiency’.

1-6 Occupied Zone

The occupied zone is a space which occupants experience the optimum climate with respect to air indoor. Areas of the room outside the occupied zone may have compromised climate, for example too high operative temperature, radiant temperature asymmetric, too high air velocity and velocity gradient. These areas can be the locations very close to the inner boundaries or the near zone of diffusers. Generally an occupied zone is defined as a space which is 0.5-1.5 meter away from wall with windows, door, and radiator, and 0.25-0.75 m from external and internal walls, distance of 1 m below the ground surface for a sitting people or 1.1 m above the ground for a sitting person are used for the height of occupied zone, [25]. For a mixing system, up to 0.2 m above the floor surface can be not considered in the occupied zone. For the wall mounted diffuser, there is no typical range, because it is dependent on the dimension of diffuser, [26].

1-7 Human Comfort

First thermal model was introduced by which was on heat between body and environment by experiment [29]. "Over the researchers conducted studies adaptive comfort models and standards" [30&31]. "The fundamental and the adaptive is expressed principle: if change such as discomfort, in ways which tends to comfort [30].

"The velocity and inside occupied is another affects comfort, this depends on temperature and shown in Fig. (1-8),[38].

1-8 Objectives of the Present Work

This thesis includes a discussion of ventilation strategies including Impinging Jet Ventilation system in office room and gives assessment for three different cross sectional types of supply air duct by adopting

experimental and numerical investigation. The main objectives of the present work are:

1- Studying three different cross sectional types of supply air duct in impinging jet ventilation system to obtain the lower overall draught discomfort type and gives more acceptable agreement between all types. Also to reach a suitable "air distribution system not only promotes a comfortable and healthy environment for occupants, but also contributes to energy conservation" which gives a more nearest to the standard Iraqi Cooling code.
2- Studying the IJV Performance and determine the Air Distribution Performance in Index (ADPI), effective temperature, and the validation efficiency at different levels of opening air outlet terminal from the room foot level. ($\geq$0.14h above the foot level)
3- Build experimental model with IJV system to obtain the indoor air quality (IAQ) and humane comfort at different cross sectional type of supply air duct and at different situations of occupant distribution.
4- To obtain comparison between experimental and numerical results to reach the acceptable agreement.
5- To reach the acceptable situation of occupant distribution which gives the optimum human comfort and air distribution.

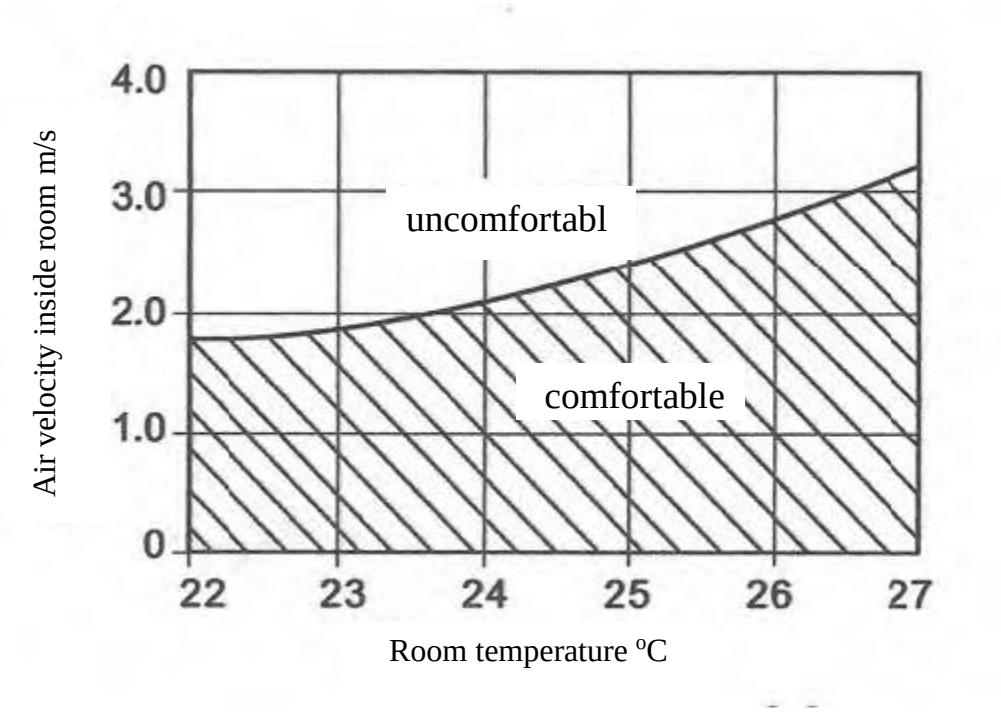


Fig. (1-8) thermal comfort zone (depend on air velocity), [36]