PERFOMANCE IMPROVEMENT OF HOT-AIR NOZZLE SYSTEM OF TEXTILE MACHINE

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ABSTRACT

Drying is one of the complex and highly energy-consuming process unit operation used in many industry such as textile, paper, chemical, pharmaceuticals, ago and food-processing, sugar, etc. Significant efforts are underway in last more than a decade to enhance dryer technology and operation to enhance its energy efficiency. In Textile Drying Machine Drying and Heat Treatment to Fabric is a process were liquid water is Evaporate by Heated Air and perform Heat setting and finishing of Fabric. Drying the Fabric involve two processes. Energy has to be provided to change the water from liquid to vapor and air stream is needed to remove water vapor. There is require higher the airflow passing through fabric gives higher efficiency to drying. Fundamentals of drying include the drying curve and moisture content. Its shows that better the air flow distribution over the system gives uniform quality of product overall direction.

Keywords:- *Textile dryer, Air Flow Distribution, Heat Transfer*

1. INTRODUCTION

The most common of Textile is used for clothing and for container such as bags and baskets. In the household, they are used in carpeting, upholstered furnishings, Window shades, Towels, beds, and other flat surfaces, and in art. In the workplace, they are used in industrial and scientific processes such as Filtering, Drying, Heat setting, Curing, Dyeing. Textiles are often dyed, with fabrics available in almost every color. The dyeing process often requires several gallons of water for each pound of clothing. Drying the cloths involve two processes. Energy has to be provided to change the water from liquid to vapor and air stream is needed to remove water vapor. Interesting observation is that the great part of water is present as capillary water held between the fibers. The main purpose of the fabric pre-treatment process is to remove oil, grease and other materials and to whiten the grey cloth though bleaching. The various process adopted in pre-treatment are scouring, bleaching and shrinking process. Dyeing is the process of imparting colors to the material through a dye (color). [1] There dye is applied to the substrate in a uniform manner to obtain an even shade with a performance and fastness appropriate to its final use. After whitening/dyeing, the fabric is unloaded from the machine and taken to the folding and rolling machines for improving the width of cloth, which gets shrunk during the washing and dyeing process. The fabric after print paste transfer is passed through a drying chamber. The dried and printed fabric is taken for further processing. Drying is also required After printing, the drying process is performed in machine, where the temperature is maintained for better color setting. After passing through the loop machines, the printed fabric is washed in a series of normal water and hot water washing in the presence of chemicals for color setting. After completion of the washing process, the printed and washed fabric is subjected to heat setting process in Dryer and then pressing and finishing treatments that gives final finished product.

TEXTILE DRYER

Textile Dryer is used for squeezing of fabrics; this machine is to approach the length and width of fabric to pre-defined values of dimensions and also for heat settings. Shade variations and finishing of fabrics are possible in machine by applying appropriate chemicals. Recovering the constant width and squeezing of fabrics towards width is the main function of this machine. Drying machine is to heat up the fabric as per the process so that yarn properties are changed by applying heat at particular temperature and in chemical coating gives luster effect on the fabric, if there is variation in applying heat on the fabric its directly affect the quality of product by shade variation.

Types of Process can be done:

- Drying
- Heat Setting
- Finishing
- Coating

DRYING: -

The main purpose of this evaporating the liquid in the fabric up to certain residual moisture. Temperature may be reach 120°C to 190°C depending upon on fabric and desired degree of whiteness. Stenter Machine is used to do following process. With knitted fabric, this is also used to relax the fabric and to eliminate stress and shrinking in following process. Therefore, the fabric width is not increased very much but you give a lot of overfeed to allow relaxation in the longitudinal direction.

HEAT SETTING: -

In this process fabric related to thermo-set material like Polyester (PES) need certain temperature to set their properties which is known as Curing temperature. This temperature range is 180°C to 120°C.

FINISHING: -

Finishing Process is to improve fabric properties by heating process. That is perform after chemical coating on textiles.

COATING: -

Coating is the process to add some chemical in proper manner and set them on fabric. That gives fabric luster effect.

FUNCTION OF MACHINE:

1) Heat setting is done by the stenter for lycra fabric, synthetic, blended fabric, knit and woven fabric.
2) Width of the fabric is controlled by the stenter.
3) Finishing chemical apply on fabric by the stenter.
4) Loop of the knit fabric is controlled.
5) Moisture of the fabric is controlled by the stenter.
6) GSM of the fabric is controlled by stenter.
7) Shrinkage property of the fabric is controlled.
8) Curing treatment for resin, water repellent fabric is done by the stenter.

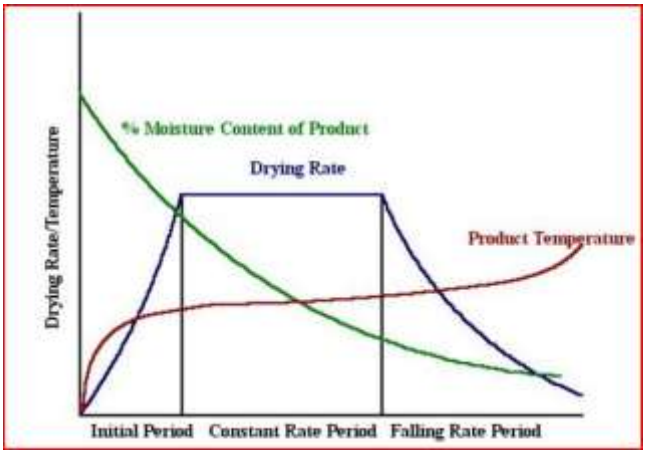


Fig. 1: Drying Curve [2]

2. LITERATURE SURVEY

- Vadiraj Katti et al. [4] This is studied the effect of jet-to-plate spacing and Reynolds number on the local heat transfer distribution. Reynolds number is based on nozzle exit condition. The regions are the identified based on flow characteristics of impinging jet. Increase the Reynolds number increase the heat transfers at all the redial location for a given space to diameter ratio. The centerline velocity of target is highest and reduces to zero at point of impact on flat surface. Experiment is conducted to measure the wall static pressure distribution at different jet-to plate spacing.
- Anja Royne et al [5] This study is Shaw that the effect of nozzle configuration on average heat transfer coefficient as well as pressure drop for jet investigated. Nusselt number is to be dependent on the nozzle diameter but there is no systematic relationship. Studies have shown that maximum average heat transfer coefficient for jets occurs at a nozzle-to-plate spacing z/d= 3 to 4.jet continuing to contract for some distance after exiting the nozzle. Thus, resulting cross sectional jet area is smaller than the nozzle area. The pressure at the center is higher than the ambient pressure at the edge, which cause the jet to continue to accelerate after leaving the nozzle until ambient pressure is achieve through the cross section. The countersunk nozzles were found to yield higher average heat transfer coefficient than the other geometry. The longer nozzle found to be lower pressure drop than shorter. Sharp edge and countered nozzles both found to higher average heat transfer coefficient when compared to straight nozzles.
- Ravish Vinze [6] In this paper describe Nusselt number measured based on equaling diameter is the highest for circular nozzle comparison with square and triangular nozzles. Nusselt numbers are in depending on jet and ambient temperature difference. Turbulent intensity at the nozzle exit affected the stagnation point heat transfer. The local heat transfer and effectiveness distributions for the square and the triangular shapes are studied. It observed that the average heat transfer rate is higher for circular nozzle compared to square and triangular nozzle. Generally, the average Nusselt number for circular nozzle is higher than square and triangular nozzles around 15%. The heat transfer increases with increase in Reynolds number. The Maximum heat transfer is achieved at approximately six nozzle diameters from the nozzle exit irrespective of jet temperature.
- Luis A Brignoni [7] It describes Heat transfer and pressure drop measurements obtain with chamfered nozzles compared with those obtained with square edge nozzle of same diameter for different turbulent, nozzle to target spacing, chamfer angles and chamfer lengths. Studies have investigated that heat transfer is also depends on nozzle geometry parameters such as nozzle diameter and length as well as the orifice inlet and exit shapes. Other than that pressure drop across the nozzle and velocity profiles along the target surface that also affected the heat transfer rate. The specific goal of this work is identifying condition under which pressure drop across the nozzle may be reduced without changing significantly altering the heat transfer rate or equivalently. At fixed flow rate a reduction in pressure drop amounts to a proportional reduction in power required to drive the flow.

- Syang-Peng Rweiand Hsin-I Pai [8] This study is describing an L/D ranging from for certain limit with 10° divergence can provide better texturing. Texturing is also enhanced when the ration of the cross-sectional area of the inlet hole versus the main channel reaches ¼. In the research use continuity and momentum equation for steady and isothermal flow of air fluid solved using no slip boundary condition on channel wall. There is use various parameters investigated that the ration of the cross-sectional area of the inlet hole versus the main channel in zone. Air inlet angle, the length of zone, Cross sectional shape of the main channel and exit divergence in zone. Various trial and after simulation results show that it is Same area of geometry but shape variation in nozzle cross-section in that rectangular section is most preferred.
- Wei-Biao Ye [9] The Air flow will flow out if the holes existed in the duct due to the static pressure difference between inside wall and outside wall of the holes. Adding vertical baffles is proposed to improve the uniform of air flow. Adding vertical baffles between fixtures cannot only improve air flow distribution greatly but also the uniformities of mass flow rates on every level are also under acceptable is concluded that the developed method with various cross sections should be useful for uniform air flow distribution in the practical duct ventilation. The outcomes of this study are powerful to assist and guide a rapid design for the uniform air flow distribution

Working procedure of machine [3]

The fabric is collected from the batcher and then it is passed through the padder where the finishes are applied and squeeze by Press roller. Sometimes shade variation is corrected. The fabric is entered into the weft straighter, the function is to set the bow and also weave of the fabric is gripped by the clips and pins. The pins have a disadvantage that they make holes at the selvedge but the stretching of the pins is greater than the clips. These clips and pins are joined to endless chain. There are 8 to 10 chambers provided on the machine each chamber contains a burner and filters are provided to separate dust from air. The circulating fans blow air from the base to the upper side and exhaust fans sucks all the hot air within the chambers. Attraction rollers are provided to stretch the warp yarn.

The textile industry is one of many industries that utilize large volumes of water in the manufacturing process. In the last three decades, the development of research related to drying has grown exponentially. In the textile industry, the drying process is one of the major cost elements among the textile finishing operations, directly affecting the specific energy consumption and the quality of the product; therefore, a proper understanding of drying is of great importance.

Drying is necessary to eliminate or reduce the water content of the fibers, yarns and fabrics following wet processes. The drying process for fabric usually involves two steps: the first one is aimed at removing water which is mechanically bound to fibers, while the second one is necessary to dry completely the fabric. Temperature of each chamber is controlled individually.

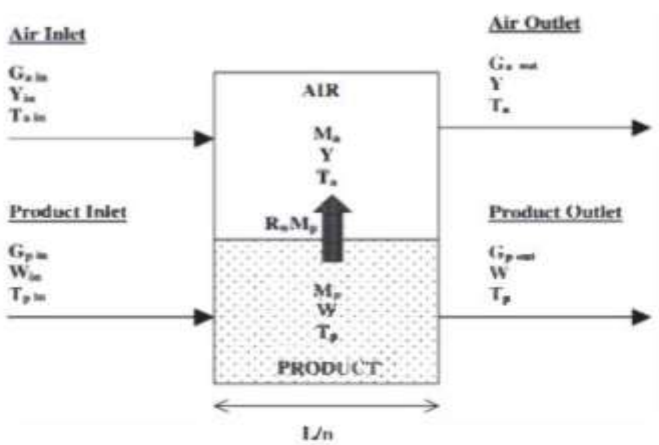


Fig.2: Control Volume of Dryer

Factors affecting the Evaporation

- Motion of air
- Nature of liquid
- Increase in surface area
- Temperature

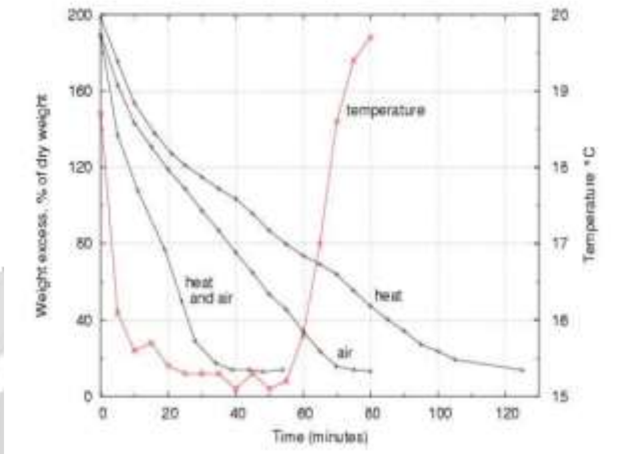


Fig 3. Drying rates for cotton cloth under various conditions [3]

The top curve is drying with heating from below so the surface remains at ambient temperature, but with no ventilation. The middle curve is for drying under ventilation at about 2m/s, but with no heating. The red curve shows the corresponding surface temperature attained by the cloth. The lowest black curve shows the rapid drying by applying both heat and ventilation, through the cloth never warmed above ambient temperature. The high-test curve, indicating the slowest drying rate, was obtained by heating the cloth to ambient temperature with no deliberate airflow. This was saying that ventilation is essential to drying and that heating just to ambient temperature will greatly accelerate drying. When the air is saturated with the evaporating substance or other substances, evaporation is slow. High pressure on a water surface reduces the rate of evaporation. Storms are examples of high-pressure systems that slow down evaporation. At a high humidity, the rate of evaporation is also low. A high rate of airflow increases evaporation. Large surface areas also facilitate evaporation. An increase in temperature facilitates evaporation by increasing the kinetic energy of the evaporating molecules. However, strong intermolecular forces or bonds reduce the rate of evaporation. This is why boiling water evaporates faster than cold water. Liquid with lower boiling point evaporate faster. Rate of evaporation is increase when there is more exposed to surface area.

Increase in temperature = Increase in Evaporation rate

Because there is no any chemical composition between Air and Water. Same for the boiling water is evaporate fast than cold water because of higher kinetic energy of water molecules.

3. DRYING SETUP

Drying happens when liquid is vaporized from a product by the application of heat. Heat may be supplied by convection (direct dryers), by conduction (contact or indirect dryers), radiation or by placing the wet material in a microwave or radio frequency electromagnetic field. Over 85 percent of industrial dryers are of the convective type with hot air or direct combustion gases as the drying medium. Over 99 percent of the applications involve removal of water. This is one of the most energy-intensive unit operations due to the high latent heat of vaporization and the inherent inefficiency of using hot air as the (most common) drying medium.

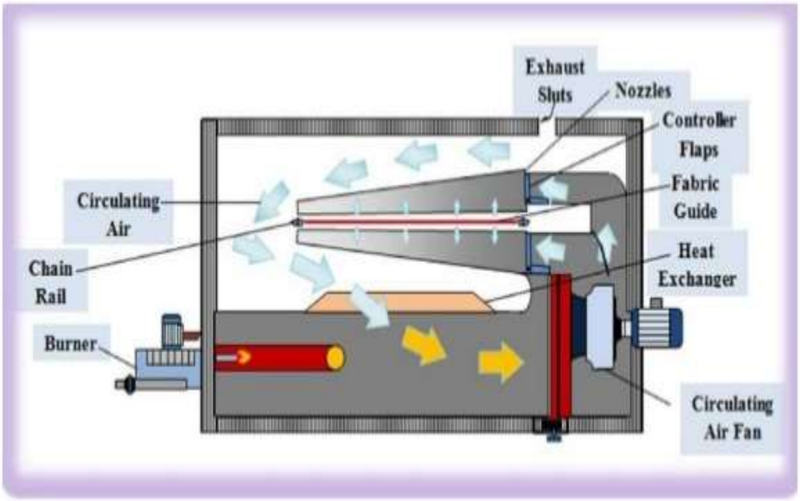


Fig.4. Air Flow Diagram

Separately control air flow for top and bottom nozzle. In the air volume is controlled by frequency inverter. Individual exact setting by speed-controlled fans even at low speeds. Ideal for delicate fabrics such as knitted goods, coated fabrics, viscose, micro-fibers, pile goods and silk. Aromatic systems for oil-heated machines in case of machine stop, the fans are stopped immediately to avoid damage or marks to the fabric. Bypass system for sensitive fabrics. There is arrangement of two fan blowers for supply of air volume to separately one for top nozzles and second blower for bottom nozzles. Based on the fan rpm there is supply of heated air to the nozzle and according to that mass of air is impinging on the fabric and heat transfer to fabric and evaporate the water in drying process as well as for supply heat for heat setting process.

INPUTS OF THE MACHINE:

- Initial moisture (%)
- Residual Moisture (%)
- Type of fabric
- Steam content in circulating air (%)
- Flow and temperature value
- Other performance parameters.
- Fabric constants
- Fabric GSM
- Machine Speed (mpm)

GSM of Fabric: - GSM refers to gram per square meter of fabric. This can be calculated as ratio of fabric sample weight & the area of the fabric sample.

Total pressure: Static pressure + Dynamic pressure

$$\Delta P = \rho g h + {v^2}/{2g}$$

For measurement in environmental condition static pressure considered as zero.

$$\therefore \Delta P = {v^2}/{2g}$$

$$\therefore v = \sqrt{2g\Delta P}$$

If ΔP is measured above 30^0C than consider as

$$\frac{\Delta P}{Density\ of\ air\ at\ t^0\ C}$$

$$\therefore v = \sqrt{\frac{2g\Delta P}{\rho}}\ \text{m/s}$$

V is the velocity of air from the nozzle outlet that give the outlet flow from various holes. Amount of air flow increase that increase water evaporation. The less amount of fresh air required the less amount of energy is utilize to heat up the air so that is directly reduce energy consumption.

Moisture evaporate% = Initial Moisture% – Residual Moisture%

Evaporate Kg H_2O/h = (Fabric GSM x Speed X Fabric Width X Moisture evaporate% x 3600)/1000

4. SIMULATION AND RESULT

This is the first step for analysis is to give engineering data or material properties should be given to the model. The material used for the Fan model is structural steel. All the parts of the assembly are made of same material. For CFX there is generate Fluid domain so only Fan has a applied material taken as solid domain. ANSYS workbench is also giving a freedom to apply the material individually for each part of assembly from the engineering data by changing its properties or by adding the material from the material library of ANSYS. For fluid domain, there is generate material Air at 200°C as engineering data density and viscosity is set for air. Here it is model is generated for setup of Dryer system of Hot-Air Nozzle system that is supply the heated air by using set of nozzles on the floating fabric. Separate system is developed for Air supply for upper side and lower side of the fabric, so that it is individually controlled air flow in both system. In this system when air is supply by using Fan blower there is variation in air mass flow in nozzle inlet that is directly affect the hot air flow impingement on fabric for drying and heat setting process. Different boundary conditions setup for the simulation. Inlet is setup at Fan blower, wall is setup as stationary region and Fan blade is rotating region.

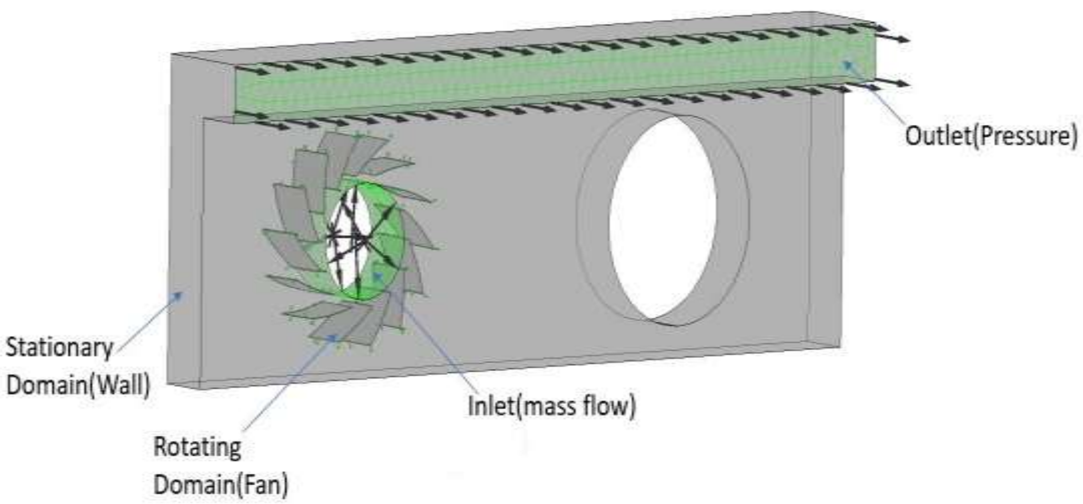
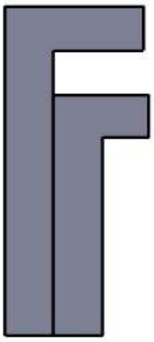


Fig 5. Setup for Simulation

With change of various inlet conditions take out outlet values of system. By study the results and literatures survey updates is done as per results found in simulation. Same conditions are applying and simulate new generated system and optimize the variation on Air distribution in system. After getting the converged meshing of model, final boundary conditions are applied to the model. Model consisting of one fan is rotating in some range of RPM. The impeller region is operating in rotating frame of reference and casing region in stationary frame of reference. As boundary condition mass flow air at inlet and average static pressure is specified at outlet. Fan is rotated in Anticlockwise direction when seen from door side of chamber. All wall is considering as no slip wall. And Set for min iteration is 1 and max. 100 iteration is set to resolved for result. For CFX there is best option to input take as Mass Flow inlet and pressure outlet that is give better results than other boundary conditions.



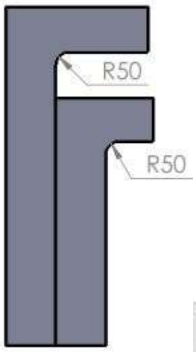
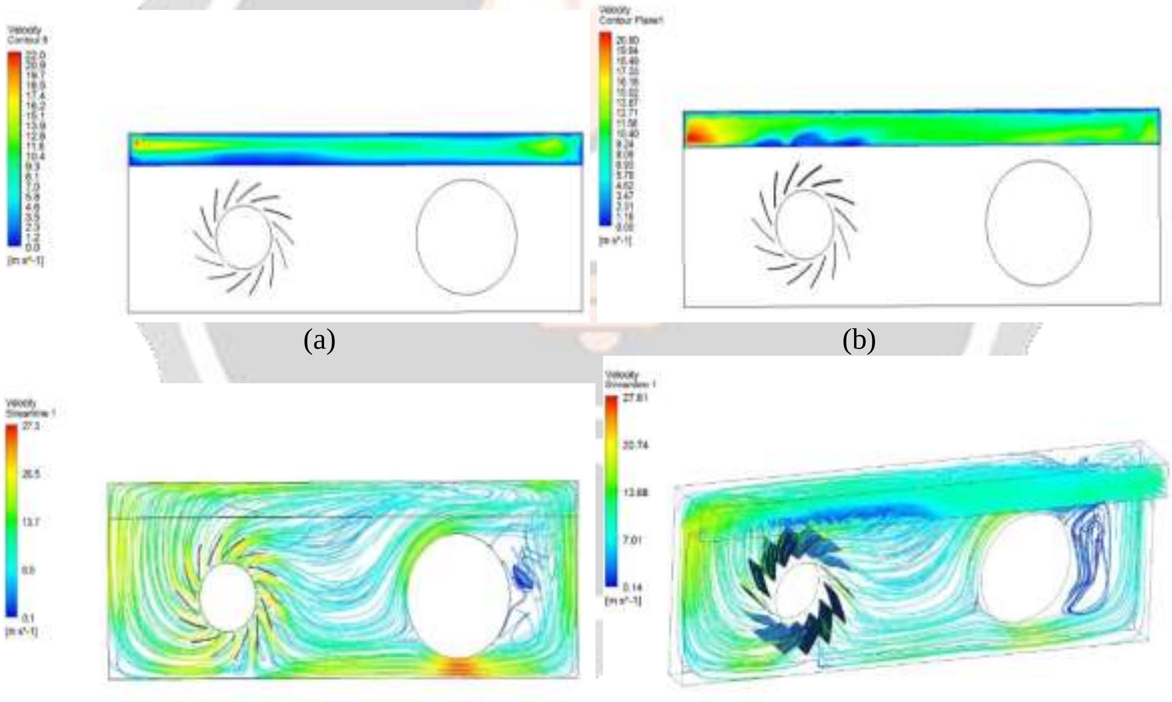


Fig.6 Existing Model **Fig.7 Proposed Model**

By changing the geometry condition there is change in air flow diagram. It is reducing air velocity drag due to sharp corner as well as by providing better adjustment with the position of Fan and blower it gives better results for Air flow inlet at Nozzle. It is directly proportional to air mass flow outlet from the Holes.



(a) (b)

(c) (d)

Fig.8 Simulation results (a), (b) Velocity Contour
(3), (4) Streamline Velocity diagram

Here (a) is existing system air velocity profile is indicated at outlet plane that is work as inlet for Nozzles used for air impingement on fabric. Result is shows that variation of air distribution over the length of system is found as well as upper and lower portion of the outlet has variation. Because of that nozzles getting different air volume and that is effect on fabric drying quality. When its geometry is update and simulate with same boundary conditions, there can be seen that by changing the geometry sharp corner to radius it gives better air flow profile in velocity contour result (b) as well as in streamline path less air velocity variation in system volume. It is to be noted that less air drag higher the air flow velocity can be achieved and that is gives higher outflow air volume through nozzle hole. Higher the air volume pass from floating fabric its gives better efficacy to drying rate and due to more uniform distribution over the length of system gives better quality of Drying than pervious system.

CONCLUSION

In the Textile Treatment Process if there is variation in various parameter like as Air Flow distribution, Air Velocity or Temperature Variation it effects the Fabric Quality, Machine operation speed, Efficiency and color shade variation. The amount of water evaporation rate increase that increase the machine speed. System start the smoke out if the fresh air volume is too low and chemical are evaporating from the fabric is higher. Production speed can be higher when the steam content in circulating air is low. The fresh air is must be heated up to process temperature that cost a heat energy. Higher the Production speed lower the production costs per meter fabric, Higher the fresh air volume, the higher are the energy costs for heating up to Process temperature, that means reused the Air as much as possible that available in system. So better the air flow is distributed evenly in the system that gives uniform air flow out from nozzle hole and Uniform quality of drying quality can be achieve.

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