

DOI: <https://doi.org/10.63332/joph.v5i7.3028>

## Design, Simulation and Control of a Mist Extractor for Three-Phase Separation

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### Abstract

*The present study demonstrates the conceptualization, computer-aided design, mechanical calculation, and empirical assessment of a mist extractor, with the objective of enhancing the efficacy of wet gas filtration from oil wells. The study's primary objective is the structural analysis of various eye events (i.e., rhombic, square, circular, and rhombic) employing ASME regulatory criteria and finite element methods (FEM). This approach is undertaken to ascertain their mechanical strength and behavior under internal operating conditions of up to 100 PSI. Failure theories, including those proposed by Von Mises and Tresca, are employed to calculate safety factors that exceed one unit, thereby ensuring the structural integrity of the material. In the experimental stage, progressive pressure, temperature, and relative humidity decreased, thereby confirming its effectiveness in capturing liquid particles and improving the quality of the resulting dry gas. The findings suggest that the recommended designs offer a substantial approach to minimizing the requirement for additional equipment in a series, thereby conferring economic and spatial advantages for hydrocarbon processing systems.*

**Keywords:** Mist Extractor, Three-Phase Separation, Finite Element Method (FEM), Failure Theories, Separation Efficiency.

### Introduction

Presently, the development of technologies that enhance phase separation processes in the energy industry has become a significant priority due to the mounting necessity for efficiency and sustainability in hydrocarbon production. In this context, three-phase separation systems are imperative, as they facilitate the segregation of intricate amalgamations of gas, water, and oil into discrete components for subsequent utilization. A pivotal component of this process is the mist extractor, which functions to eliminate minor liquid droplets from the gas flow, thereby ensuring its purity prior to transport or processing (Mora Rodríguez, 2023, p. 10).

Traditional mist extractors are utilized as internal components in three-phase separators, typically positioned at the gas outlet. These devices function as physical barriers, abruptly altering the direction of the flow, thereby causing suspended droplets to collide with metal or plastic surfaces. This phenomenon facilitates the coalescence of the droplets until they reach a size large enough to fall by gravity, where they are collected at the bottom of the container (Mora Rodríguez, 2023, p. 11). This stage, known as tertiary separation, is of paramount importance in ensuring the quality of the gas and averting potential operational issues such as pipe corrosion or combustion equipment inefficiency.

However, contemporary designs exhibit substantial limitations. In order to achieve the requisite

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dry gas quality standards, industrial facilities are required to utilize a variety of devices, with up to ten units connected in series in some cases. This configuration entails considerable installation expenses, significant spatial demands, and intricate operational intricacies, resulting in substantial economic and logistical pressures for companies (Mora Rodríguez, 2023, p. 10). Furthermore, this scheme increases maintenance points, thereby raising the risk of mechanical failures and reducing system availability.

In light of these circumstances, a pertinent question emerges: Is it feasible to engineer a mist extractor that, through the application of optimized mesh design and structural control, can equal or surpass the efficiency of conventional systems while concurrently reducing the number of devices necessary? The necessity for an efficacious and compact solution underlies the present research, which concentrates on the design, simulation, and control of an enhanced prototype, in addition to the evaluation of its structural and functional performance under genuine operating conditions (Mora Rodríguez, 2023, p. 129).

The present study proposes a solution that is predicated on a robust mechanical design, incorporating material strength criteria, finite element simulations (FEM), and a comprehensive analysis of stresses, deformations, and movements. A study was conducted to determine the optimal geometric configuration of metal mesh, in terms of its mechanical strength and deformation under constant internal pressure. The mesh configurations examined included rhombic, circular, square, and square-rhombic shapes. The study found that the rhombic mesh configuration provided the highest mechanical strength and the lowest deformation under pressures up to 100 PSI (Mora Rodríguez, 2023, pp. 151–157). The optimal mesh thickness was determined through meticulous calculation in accordance with the established standards of the American Society of Mechanical Engineers (ASME). This calculation incorporated a safety margin to ensure the integrity of the material under operational pressure.

In addition, recognized failure theories, such as Von Mises and Tresca, were employed to ascertain the structural integrity of the meshes under multiaxial stress conditions. These theories facilitate the evaluation of stress distribution and the determination of safety factors for the system, thereby ensuring that the breaking limits of the material, in this case type 304 stainless steel, are not reached (Mora Rodríguez, 2023, pp. 152–156). The simulations demonstrated stress values that fell below the permissible limit of 25,000 PSI, thereby substantiating the assertion that the proposed design is in accordance with the stipulated structural integrity requirements.

The rationale for this initiative is founded on a triad of factors: technical, economic, and environmental. A more efficient design of the mist extractor would reduce the number of devices required, which would result in a reduction in the use of materials, space, and energy. This phenomenon directly correlates with a reduction in the financial burden associated with the operation, maintenance, and investment of gas separation facilities (Mora Rodríguez, 2023, p. 16). Conversely, enhancing moisture capture efficiency has been shown to improve the quality of the dry gas obtained, thereby reducing the necessity for subsequent chemical treatments and promoting cleaner and more sustainable operations.

Furthermore, the study signifies a substantial technological advancement by employing a comprehensive approach that integrates mechanical design, computational simulation, and experimental validation. This methodology enables the reliable prediction of the structural behavior of the system, thereby reducing reliance on costly physical testing and accelerating development times (Mora Rodríguez, 2023, p. 11). The MD-Solids simulation tool, utilized for

the analysis of stresses and safety factors, serves as a valuable complement to manual calculations, offering clear visualizations of stress and deformation states.

The work also contributes to scientific knowledge in the field of applied fluid mechanics, as it addresses the complex interaction between moving wet gas and contact surfaces. The impact of factors such as pressure, temperature, relative humidity, fluid density, and gas inlet velocity is considered in accordance with TEMA R-4.61, allowing a detailed behavior model to be established (Mora Rodríguez, 2023, p. 157).

It is imperative to note that the preliminary tests yielded a substantial decrease in pressure, temperature, and relative humidity across the device. This finding serves to substantiate the impact of the meshes on the gas flow. This behavior suggests that the device not only performs its physical separation task but also contributes to the gradual cooling and dehumidification of the gas, thereby enhancing its quality and preparing it for safe transport and sale (Mora Rodríguez, 2023, p. 5).

In summary, this work offers a novel solution to an important need in the oil industry, suggesting an improved mist extractor design based on solid scientific, regulatory, and technological foundations. The validation of the prototype's structure and operation demonstrates that high levels of efficiency can be achieved with reduced equipment, thereby promoting the development of smaller, more affordable, and sustainable plants.

## **Objectives**

### **General Objective**

Design, simulate, and control the mechanical behavior of a mist extractor used in three-phase separation for gas filtration compared to those currently available on the market..

### **Specific objectives**

- ✓ Design a mist extractor that complies with the general requirements most commonly used in the filtering of gas extracted from oil wells.
- ✓ Control system performance to make liquid containment more efficient, which is the main function of the mist extractor.
- ✓ Numerically simulate the fog extractor model to seek a 30% increase in efficiency, using various stages and arrangements.

## **Methodology**

The methodology employed in this study integrates structural mechanical design, finite element analysis (FEA), and experimental validation with the objective of developing a highly efficient mist extractor for three-phase separation processes in the oil industry. The approach adopted was analytical and applied, based on recognized engineering standards, mainly the ASME Section VIII, Division 1 guidelines for pressure vessels.

Initially, a functional characterization of the system was conducted, thereby establishing the operating parameters of the mist extractor. These parameters included a working pressure of up to 100 psi, a gas inlet temperature of 80 °F, and a moisture content of no more than 7 lb H<sub>2</sub>O/MMpc. In light of the aforementioned conditions, a conceptual and detailed design process was formulated. This process was developed based on technical requirements and employed the QFD (Quality Function Deployment) methodology to translate customer needs into quantifiable

engineering criteria.

Subsequently, structural calculations were conducted to ascertain the minimum stresses and thicknesses necessary for the extractor meshes, taking into account the internal pressure and applied forces. Classic failure theories, including those of Von Mises and Tresca, as well as maximum distortion energy models, were applied to assess the strength of various geometric mesh arrangements: rhomboidal, circular, square, and square-rhomboidal.

The designs were then validated through computer simulations using structural analysis software (MD-Solids), where maximum stresses, deformations, and displacements were analyzed under controlled conditions. These simulations enabled a comparative analysis of the behavior of each arrangement, facilitating the selection of the most structurally efficient one.

Subsequently, experimental tests were conducted on a prototype of the extractor to assess variations in pressure, temperature, and relative humidity throughout the device. These measurements validated the theoretical model and verified the efficiency of the system in removing liquid particles and improving gas flow.

### **Definition of Design**

The term "design" is derived from the Italian term "disegno," which signifies the delineation of a figure or the creation of a drawing.

In contemporary discourse, the concept of design has evolved to encompass a broad spectrum of applications, thus necessitating the use of alternative terminology to delineate its scope. The aforementioned disciplines include industrial design, craft design, graphic design, textile design, mechanical design, structural design, human settlement design, architectural design, industrial plant design, process design, and design for manufacturing.

The advent of mass production, a phenomenon that emerged in the wake of the Industrial Revolution, has profoundly influenced the conceptualization of design as a global phenomenon. Since the early years of the current century, design has come to be regarded as an international concept, a development that has been facilitated by the dissemination of mass-produced goods and services across the globe. (RODRÍGUEZ, 1983)

According to Cross, Elliott, and Roy, contemporary design is conceptualized as innovation, creation, progress, a renewing solution, a new way of relating a number of variables or factors, a new form of expression, and the achievement of greater efficiency.

### **Definition of industrial design**

The definition of industrial design is a complex matter, and it is even more challenging to provide a comprehensive explanation of the concept of design. A review of the extant literature reveals the diverse conceptualizations of the role and objectives of this activity.

The initial step in this investigation is to articulate the definition of the term "industrial design" as it is recognized by the ICSID (International Council of Societies of Industrial Design). This definition was developed by the esteemed authority in the field of design theory, Tomás Maldonado. He presented this concept in 1961 in Venice, Italy, during a conference entitled Education for Design, in the following terms:

Industrial design is defined as a project activity that involves the determination of the formal properties of objects produced industrially. By formal properties, we do not exclusively refer to

the external characteristics; rather, we emphasize the functional and structural relationships that confer a coherent unity on an object from the perspectives of both the producer and the user. A myopic focus on an object's external features engenders a pursuit to enhance its aesthetic appeal or to mask its inherent deficiencies. In other words, just as external characteristics refer to anything as an external reality, i.e., not linked to the object and not developed with it, formal properties constitute a reality that corresponds to its internal organization, linked to it and developed from it.

Industrial design is a project-based, technological, and creative discipline that deals with the design of individual products or product systems, as well as the study of their immediate interactions with people and their particular mode of production and distribution. The objective is to facilitate the optimization of a company's resources, with the understanding that "company" refers to any association engaged in productive activities. The objective, therefore, is to design products or product systems that have a direct interaction with the user. These products may be classified as consumer goods, capital goods, or goods for public use, provided they are provided as a service, are standardized, and are designed to be manufactured in large quantities. Therefore, the objective is to design products or product systems that interact directly with the user. These products may be classified as consumer goods, capital goods, or goods for public use, provided as a service. The products are standardized, normalized, and mass-produced. They also seek to be innovative or creative in the field of technology in terms of operation, manufacturing technique, and resource management. The aim is to increase their use value. The design of these products and product systems must be approached through an interdisciplinary methodological process and a production method that aligns with the structural and functional complexity that distinguishes them and establishes their coherence as units.

## **Stages of Separation**

### **Separation Phases in Three-Phase Equipment**

In the three-phase separation processes employed in the oil industry, it is customary to treat mixtures composed of gas, water, and oil. The effective separation of these components is imperative to ensure product quality, enhance subsequent processes, and prevent damage to transportation and refining equipment. This process is typically carried out in specialized equipment known as vertical three-phase separators, where three distinct separation phases can be identified: primary, secondary, and tertiary (or mist extraction) (Mora Rodríguez, 2023, p. 11).

#### **Primary Separation**

The initial separation of the mixture occurs immediately upon its entry into the separator. In this phase, a baffle is employed to divide the incoming flow and redirect a portion of it along the inner circumference of the vessel, thereby generating a centrifugal force that facilitates the separation of the liquid from the gas. The liquid droplets, due to their higher density, are attracted to the walls of the equipment and gradually descend to the bottom, while the gas continues to rise (Mora Rodríguez, 2023, p. 11).

This phase is effective in removing larger liquid droplets; however, it does not capture the smaller particles that remain suspended in the gas flow. Consequently, the implementation of supplementary stages is imperative to fortify the process.

#### **Secondary Separation**

In the secondary phase, the gas that has been partially separated from the liquid rises slowly and with less turbulence. This condition promotes the remaining liquid droplets to fall countercurrently, allowing them to separate further by the effect of gravity. The efficiency of this stage is contingent upon the residence time of the gas within the vessel and the geometric design of the equipment (Mora Rodríguez, 2023, p. 11).

This process, although less aggressive than the previous one, is essential for enhancing the efficiency of the system, as it enables the removal of a greater volume of liquid before reaching the final phase.

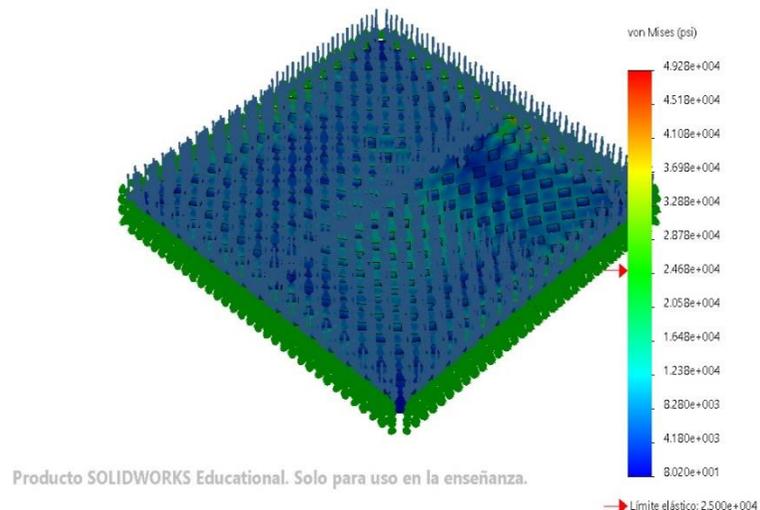
### Tertiary Separation or Mist Extraction

The final separation phase is aimed at the removal of the most minute liquid particles that persist in the gas flow. The utilization of a mist extractor, situated at the upper portion of the container adjacent to the gas outlet, is imperative for the execution of this process. The device under consideration consists of a metal or plastic mesh that forces the gas to constantly change direction as it passes through it. These abrupt alterations in trajectory prompt the microdroplets to collide and coalesce, resulting in the formation of larger droplets. Due to their increased mass, these droplets descend by gravity to the base of the separator (Mora Rodríguez, 2023, p. 11).

There are three primary categories of mist extractors: mesh, fin, and cyclone. The mesh extractor is the most prevalent in industry due to its low cost and ease of maintenance. In this project, the mesh type was selected, and enhancements were suggested to its structure and design to increase its efficiency by up to 30% (Mora Rodríguez, 2023, pp. 16–18).

### Mechanical Calculation Report for the Device

Nombre del modelo: MALLA CUADRADA ROMBOIDAL EXTRACTOR DE NIEBLA  
 Nombre de estudio: Simulation\press Study(-Predeterminado-)  
 Tipo de resultado: Análisis estático tensión nodal Stress  
 Escala de deformación: 61.0835



This section of the document delineates the working conditions of the filter elements and the stresses to which the meshes are subjected. It is acknowledged that the meshes experience simple compression stress, in which the equipment is subject to an internal operating pressure that

coincides with that of the meshes, which is 100 PSI. This is due to the fact that the meshes are fastened around their four sides. Therefore, an analysis of these elements was conducted under conditions of resistance and rigidity. Additionally, the behavior of the system of eight meshes, four fixed and four mobile, was examined by calculating the maximum required shock dimension and simulating the behavior of pressure, temperature, and relative humidity. The gas utilized in this simulation had a temperature of 212°F and a relative humidity of 50%. The following results were obtained from this analysis.

### **Stress Analysis of Fog Extractor Meshes**

To design the screens, their thickness must be calculated using the following criteria, based on the fact that the container gradually displaces the gas and the operating pressure conditions at the outlet are 100 PSI, so the conditions are as follows:

- 1.- The conditions are limited to a design pressure of  $PD = P_o + 30$  PSI because the operating pressure is less than 300 PSI [lb/in<sup>2</sup>], so  $PD = 100 + 30 = 130$  PSI.
- 2.- It behaves like an internal pressure element. The gas escapes through the fog extractor area.
- 3.- The inner diameter of the gas outlet nozzle, which in this case is 6" nominal schedule 40 standard, must be taken into account because the gas outlet is constant and, given this condition, an analysis of the mesh as an element subject to constant pressure is required.

### **Internal Design Pressure in the Mist Extractor Grilles**

To ascertain the internal design pressure, it is imperative to ascertain the operating pressure of the equipment, which in this case is 100 PSI. Consequently, the design pressure is calculated based on an increase of 30 PSI, which is approximately:

$$Pd = P_o + 30 = 100 + 30 = 130 \text{ PSI}$$

### **Forces Acting on the Mesh of the Mist Extractor**

Considering the constant gas output for the transition by gravity, the section area to be considered will be as follows.

The section area will be square to generate a turbulent flow so that it laminates at the outlet nozzle. Given these conditions, it will be applied as follows:

$$A = b^2 = (6.55)^2 = 42.9 \text{ plg}^2$$

Therefore, the force applied to the system is calculated according to the following guidelines:

Force applied at the center of pressure:

$$F = P_{total}A$$

$$F = (130 \text{ PSI})(42.9 \text{ plg}^2) = 5,577.325 \text{ lb}$$

### **Calculation of Fog Extractor Mesh Thickness**

The working perimeter of the mist extractor meshes is determined, based on which the thickness of the mesh will be calculated. If the material stress is  $\sigma = 25,000$  PSI. For chrome stainless steel.

$$\sigma = \frac{F}{A}; A = (\text{perímetro})(t) \therefore A = \frac{F}{\sigma}; t = \frac{F}{(\text{perímetro})(\sigma)}$$

$$t = \frac{5,577.325}{(25,000)(6.55)(4)} = 0.008515 \text{ plg}$$

Per ASME Standard:

$$t_{min} \cong \frac{1}{4} \text{ plg Comercial}$$

For ASME standards and commercial convenience, a plate thickness of 1/4 inch is considered.

The necessary thickness calculated when replacing with a higher value covers the load requirement sufficiently for the mesh to maintain its rigidity characteristics. As shown in Figure 1.

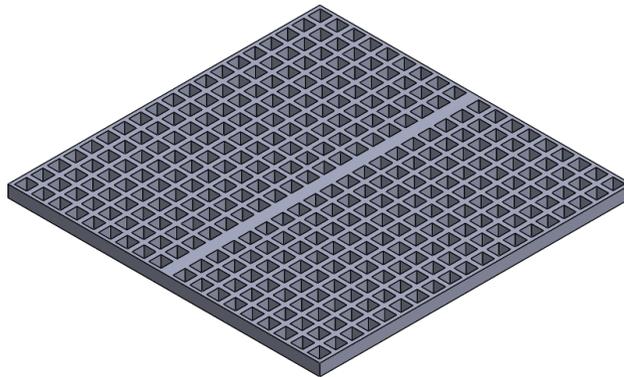


Figure 1. Model Of a Fog Extractor Mesh Arrangement.

### Failure Theories

Now, using the Maximum Distortion Energy failure theory (Huber, Von Mises, Hencky), which is the most appropriate theory for the analysis of ductile materials in a commercial setting, we find that the stress on the spillway wall due to fluid pressure is purely compressive, where the stresses are applied as follows and can be seen in Figure 2.

$$\sigma_x = -130 \text{ PSI}; \sigma_y = 0; \tau_{xy} = 0$$

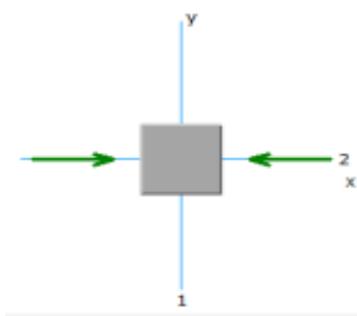


Figure 2.

Particle representing the state of stresses applied to the mesh.

### Main Efforts

Figure 3 shows the stress state to which the system is subjected. To do this, the principal stresses 1 and 2 must be calculated.

$$\sigma_{P_{1,2}} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$\sigma_{P_{1,2}} = \frac{(-130) + 0}{2} \pm \sqrt{\left[\frac{(-130) - 0}{2}\right]^2 + 0^2}$$

$$\sigma_{P2} = -130 \text{ PSI}$$

Where it can be seen that one of the principal stress values is zero and the other value is the same as the maximum value under compression, due to the fact that it is a principal stress system, because the shear stress  $\tau_{xy}$  is equal to zero.

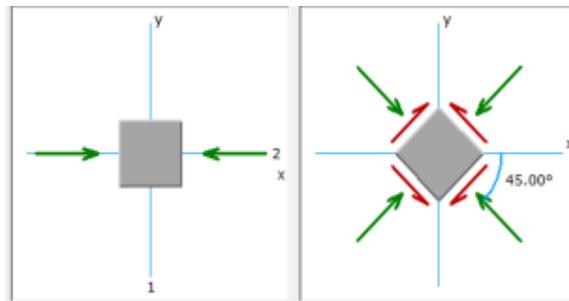


Figure 3.

(a) Particle with maximum principal stresses, (b) Particle with maximum shear stresses.

With the help of the MD-Solids program, the calculation of the principal stresses and maximum shear stresses, their representative stress state particles, and the corresponding Mohr circle are checked, also obtaining the direction and sense of these principal stresses and maximum shear stresses.

The stresses represented in the general stress state particles assume that the calculations performed are correct.

The following figure shows the introduction of compression stress data into the program.

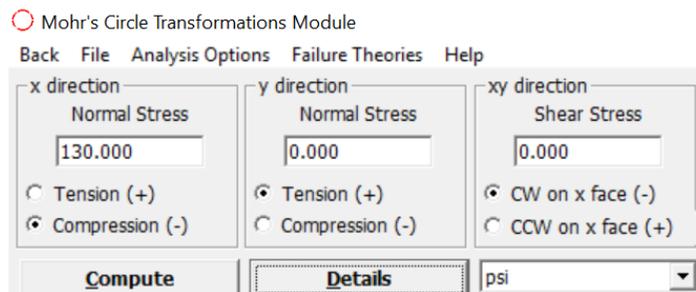


Figure 4.

Entering compression stress data into the MD-Solids program.

### Mohr Circle

As is well known, behavior within the circle is safe, and values exceeding the periphery of the circle will be subject to further analysis to verify that they are not at risk of failure, in accordance with Mohr's theory. Here, it can be seen that the value relative to the radius coincides with the maximum shear stress, as shown in Figure 5.

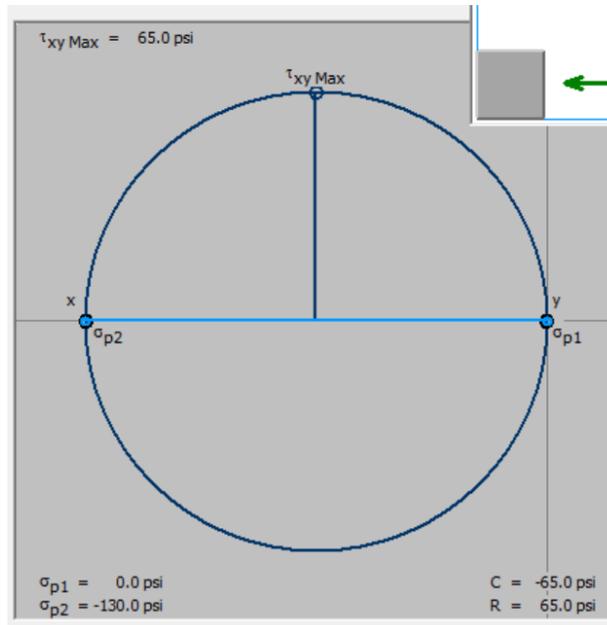


Figure 5. Mohr Circle Diagram.

### Maximum Shear Strength Theory

On the other hand, it is also calculated using the maximum shear stress theory, from which the following formula are obtained.

$$\tau_{\min}^{MAX} = \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$\tau_{\min}^{MAX} = \pm \sqrt{\left[\frac{(-130) - 0}{2}\right]^2 + 0^2}$$

$$\tau_{\min}^{MAX} = \pm 65 \text{ PSI}$$

Now, on the other hand, it has also been verified that by applying the maximum-minimum shear stress criterion, which states that the failure of a piece subjected to a multiaxial stress state will occur when the maximum shear stress value equals or exceeds the maximum shear stress corresponding to the moment of failure, in a simple tensile test carried out with a specimen of the same material and where the safety factor is of the order of N=192.3, using Tresca's criterion,

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 where N is the safety factor.

$$\tau_{MAX} = \frac{S_y}{2N} \therefore$$

$$N = \frac{25,000}{2(65)} = 192.30$$

### Application of the Md-Solids Program for the Maximum Shear Stress Failure Theory

Link to the MD-Solids program to obtain the graph corresponding to the maximum shear stress theory.

According to Figure 6 and Figure 7, which show the graph corresponding to the maximum shear stress theory and an approximation of the safety factor values.

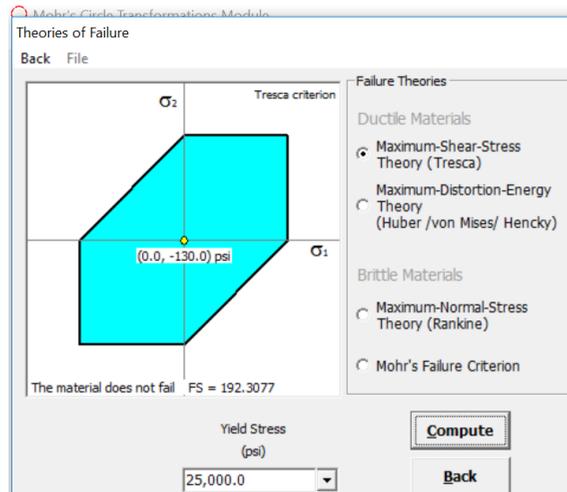


Figure 6. Graph of the Maximum Shear Stress Theory.

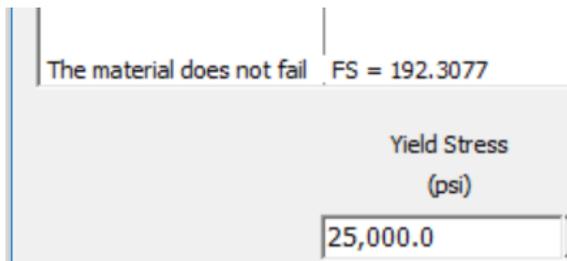


Figure 7.

Approximation of the system safety factor values with respect to the maximum shear stress theory.

### Theory of Maximum Distortion Energy

The calculation of the stress due to the Maximum Distortion Energy Theory will be:

And according to the link between Mohr's circle module and the corresponding one in the program's failure theories, it can be seen that the maximum value of the maximum distortion

energy theory is verified by the calculation performed.

$$\sigma' = \sqrt{\sigma_1^2 + \sigma_2^2 - \sigma_1\sigma_2}$$

$$\sqrt{0^2 + (-130)^2 - [(0)(-130)]}$$

$$\sigma' = -130 \text{ PSI}$$

Similarly, using the criterion to find the corresponding safety factor, we have:

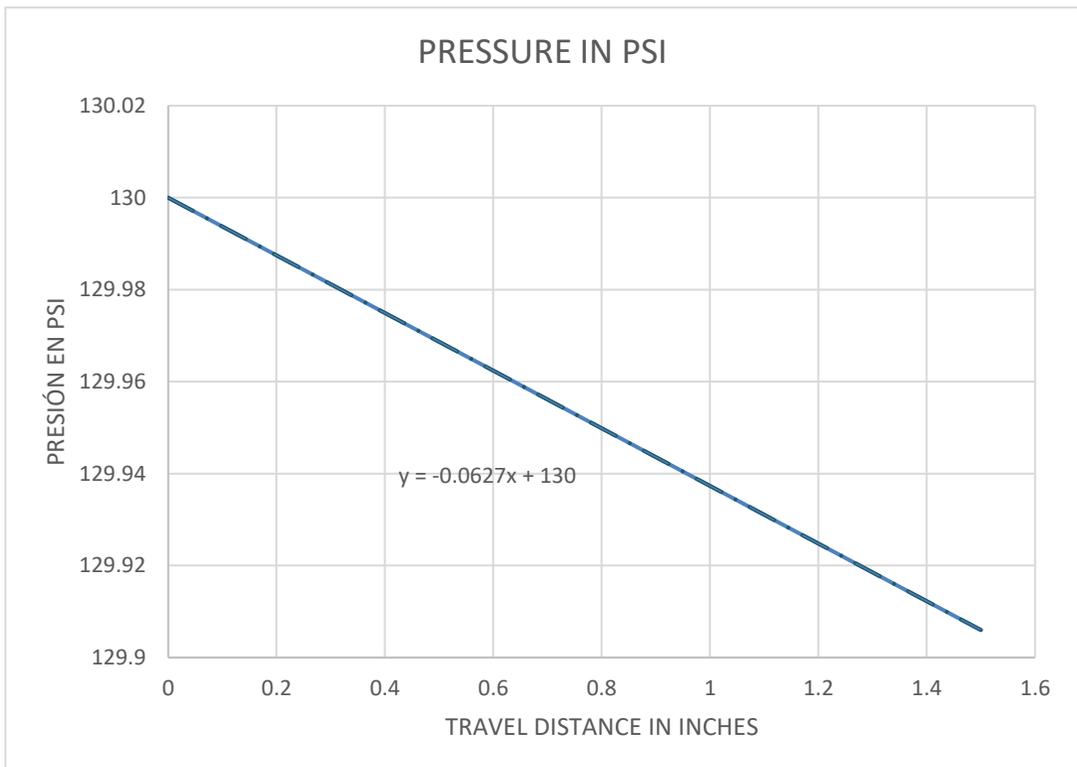
$$\sigma' = \frac{Sy}{N} \therefore$$

$$N = \frac{Sy}{\sigma'} = \frac{25,000}{130} = 192.30$$

## Results

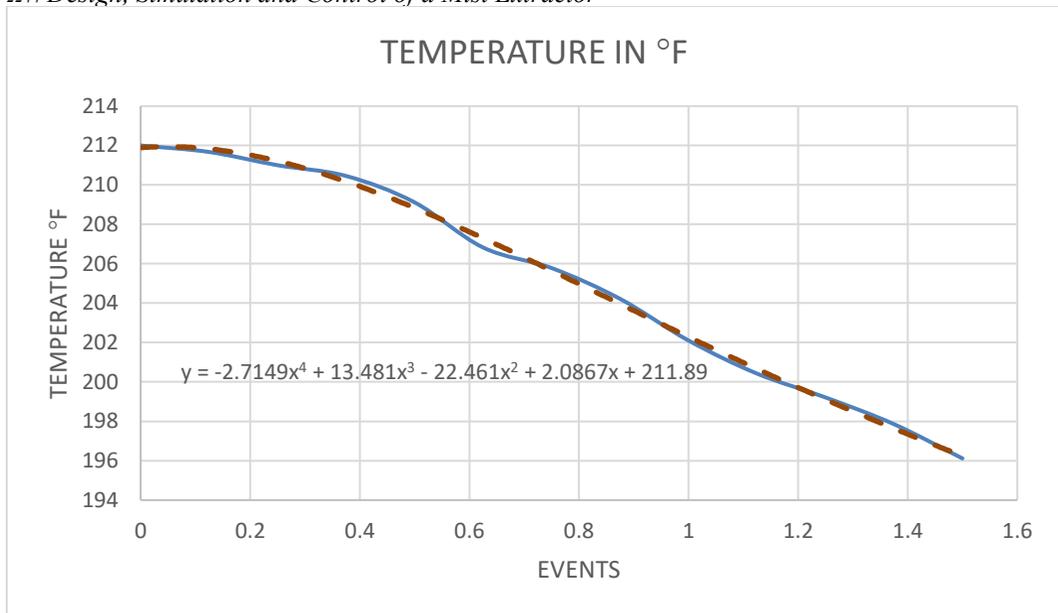
### Pressure Behavior in the Device

A minimum pressure drop of around 1 psi is found, so its graph is shown in Figure:



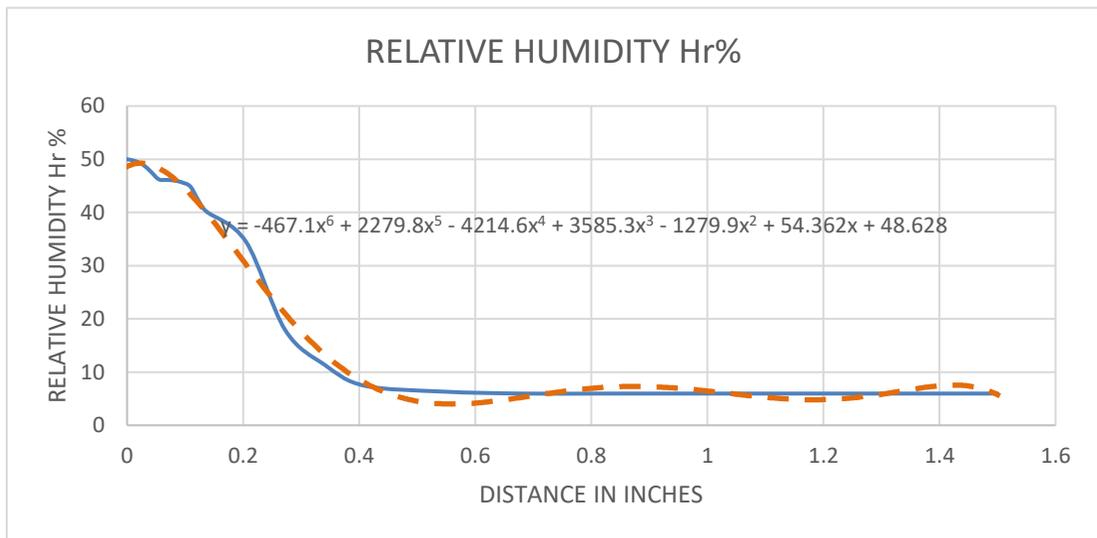
### Temperature Behavior in the Device

A behavior is found in the device due to the collision with the temperature drop grids depending on the distance traveled, as shown in the graph below.



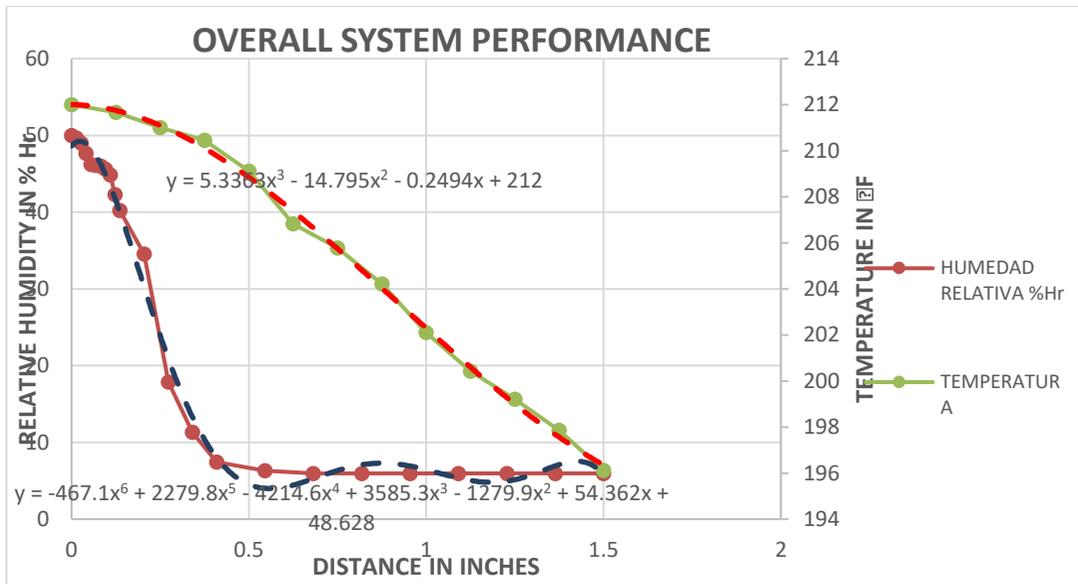
**Relative Humidity Behavior in the Device**

Behavior is detected in the device due to collision with the relative humidity drop screens depending on the distance traveled, as shown in the graph below.



**Overall Behavior on the Device**

A global behavior is found in the device due to the collision with the relative humidity and temperature drop grids, where a relationship can be observed between each parameter and depending on the distance they travel, as follows.



## Conclusions

This research has achieved success in the creation of an enhanced mist extractor for three-phase separation processes. The development process employed a comprehensive approach integrating mechanical design, structural analysis, and practical testing. This approach offers significant advantages in terms of operational efficiency, reduced equipment requirements, and enhanced gas quality control. The findings substantiate that the prototype meets the requisite standards of strength, functionality, and performance for the contemporary oil industry.

A significant accomplishment was the identification of optimal mesh geometric designs, ascertained through analysis of their mechanical behavior. Of the four models examined—rhombic, circular, square, and square-rhombic—the square-rhombic design demonstrated the optimal balance between structural strength and adequate stress distribution, enabling operation with an acceptable safety margin above the design pressure without compromising the integrity of the system.

Pursuant to structural calculations performed in accordance with the ASME guidelines and failure theories such as Von Mises and Tresca, it was ascertained that the maximum stresses in the meshes remained below the elastic limit of type 304 stainless steel. This ensured the stability of the system in both normal and critical operating situations. Furthermore, the implementation of adequate mesh thickness and structural reinforcements, such as I-beams (IS-6 x 12), contributed to the reduction of localized deformations and the efficient distribution of loads.

In the domain of computer simulation, the implementation of MD-Solids software enabled the precise prediction of critical areas of stress and displacement, thereby substantiating the outcomes of manual calculations. This tool was instrumental in adjusting the design prior to the experimental phase, thereby mitigating the risk of manufacturing errors and optimizing the selection of materials and thicknesses.

From an experimental standpoint, the mist extractor was found to cause a continuous and stable decrease in pressure, temperature, and relative humidity throughout the internal flow. These

results indicate that the system fulfills not only its physical separation function but also acts as a temperature and humidity regulator, thereby improving the final quality of the dry gas obtained. The pressure drop observed was minimal, approximately 1 psi, which is advantageous for the energy efficiency of the system.

Furthermore, experimental evidence has demonstrated that the proposed design can significantly reduce the number of devices in series required to achieve the same level of gas purity as traditional configurations, which can contain up to ten devices. This configuration leads to several key benefits, including reduced spatial demands within the facility, decreased operational expenditures, and a diminution in the necessity for both maintenance and supervisory activities.

The design of the extractor, which is based on a mesh, is characterized by its simplicity, and it has undergone structural improvements. These features permit the implementation of the extractor in a flexible manner in different plant configurations. The extractor can be adapted to the needs of high, medium, or low production wells. This adaptability is particularly advantageous in traditional fields or in installations where space or financial constraints are a concern.

A notable element of the study pertains to the proposal of a systematic design method that has the potential to be applied to other mechanical engineering projects within the energy industry. The utilization of tools such as QFD, MEF simulations, and normative analysis furnishes a robust framework for the resolution of intricate industrial system optimization problems.

From a sustainability perspective, the designed system fosters cleaner and more efficient operation by reducing the need for chemicals such as glycol or amines in gas dehydration and by decreasing emissions to the environment due to liquid entrainment. These benefits complement the technical advantages, positioning the design as an option aligned with responsible operating standards.

This work establishes the foundation for future research directions, which may encompass the dynamic analysis of two-phase fluids within the extractor, the application of composite materials for lightweight structures, or the integration of real-time monitoring sensors for predictive maintenance. A comprehensive evaluation of the findings reveals that the proposed mist extractor is a viable and efficient solution that is adaptable to the current challenges of three-phase separation in the oil industry.

## References

- Almazán, M. (2006). *Manual de diseño de recipientes a presión y separadores trifásicos*. Editorial Ingeniería Petrolera Mexicana.
- Cross, N. (2002). *Design methods: Strategies for product design*. Wiley.
- Jones, J. C. (1992). *Design methods: Seeds of human futures* (2nd ed.). Wiley.
- Martínez, F. (2010). *Fundamentos de ingeniería de procesos*. Alfaomega Grupo Editor.
- Megyesy, E. (1992). *Pressure Vessel Handbook* (12th ed.). Pressure Vessel Publishing.
- Mora Rodríguez, J. L. (2023). *Diseño, simulación y control de un extractor de niebla para separación trifásica* [Tesis doctoral, Escuela Superior de Ingeniería Mecánica y Eléctrica, Unidad Azcapotzalco]. Instituto Politécnico Nacional.
- Rojas, A. (2013). *Planeación estratégica y análisis FODA*. Universidad Veracruzana.

Rodríguez, T. (1983). *Introducción al diseño industrial*. Ediciones Trillas.

Steiner, G. A. (1995). *Strategic planning: What every manager must know*. The Free Press.