# Improvement of Paterson Kelly V-Blender Ventilation System

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## Abstract

This paper presents the successful improvement and implementation of ventilation system modifications in a Patterson Kelly V-Blender used in Upjohn (Pfizer Division) Pharmaceutical located at Barceloneta, Puerto Rico. The purpose of this research was analyzing and resolve the equipment reliability issues and flexibility generated by the introduction of new product with different formulation in the blending process. Results were analyzed and documented in a report. The research results show that the ventilation improvements preformed to the Patterson Kelly V-Blender system were capable of maintain the required process parameters without interruptions. Also, provide the flexibility of the system by running products with different formulation (solvent-based and water-based product) resulting in an increase manufacturing production.

## Introduction

The V-Blender equipment are commonly used in pharmaceutical industry for precise formulations. V-blenders are characterized by their V-shape that comes from having two connected blending shells. The V-shape creates more efficient blending of solids to solids or solids to liquids. This blender type use diffusion, or the random motion of solid particles, to get the job done.

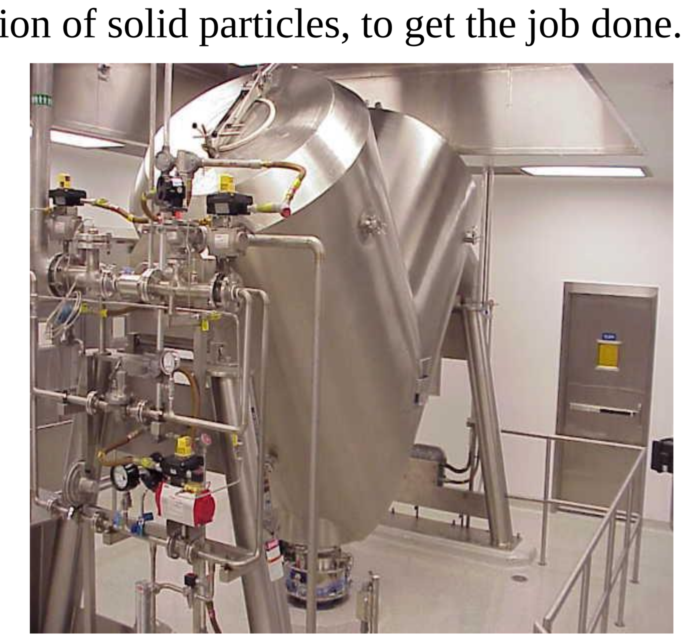


Figure 1: Patterson Kelly V-Blender

## Problem

Upjohn Pharmaceutical has a V-Blender used for wet granulation and drying solvent-base products (Ethanol Solvent). As part of the manufacturing products expansion a water-based product was included in the V-Blender process schedule. The integration of the new product created interruptions between the wet granulation and drying phase of the process that impact the product supply during the first manufacturing lots.

## Methodology

The methodology applied in the research study was DMAIC process.

- **Define:** Problem and identify the possible improvements.
- **Measure:** What characteristics determine the behavior of the process.
- **Analyze:** Analyze the data to determine the root cause.
- **Improve:** Propose and develop a solution(s)
- **Control:** Ensure that the process maintains the gains.

## Process Analysis

V-Blender process and operation analysis show that the root cause of the interruptions between the granulation and drying phase occurs in the ventilation system by the water-based composition of the new product. When the V-Blender is used to granulate water-based products the VOC Condenser, set at temperature of 17°F, causing carry over water droplets until freeze and plug the VOC condenser.

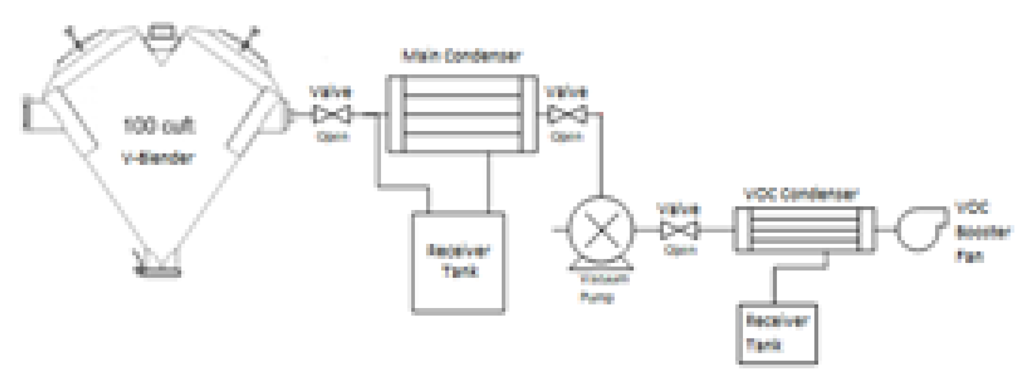



Figure 2: V-blender Ventilation System Schematic

For new process the VOC condenser was not required because no solvents emissions will be release to the environment.

The proposal was designing a condenser for the water vapor based in the process parameters and install at the outlet of the vacuum pump bypassing the main condenser, the receiver tank and the VOC Condenser.

## Tests and Results

Helical Coil condenser was designed based in the system parameters and the utilities availability in the mechanical room area [1].

Equations used for Helical Coil Condenser design:

**Heat Loss** $Q = M*500*Cp*\Delta T$

**Sensible Heat** $Hs = 1.08\, q\, \Delta T$ (Btu/Hr)

**Heat Transfer Surface Area** $A = Q / LMTD*U$

**Length of the Coil** $L = Q/\pi d$

**Theorical Number of turns of Coil** $N = L/((2\pi r)^2+P^2)^{1/2}$

**Length of the Condenser Shell** $L_{Shell} = N * P$

| Helical Coil Condenser | |
|---|---|
| Heat Loss = Q | 76,198.08 BTU/Hr |
| Sensible Heat (Hs) | 4,698 Btu/Hr |
| Heat transfer Surface Area | 4.19 ft$^2$ |
| Length of the Coil | 64.09 ft |
| Theorical Number of N turns for coil | 21 turns |
| Length of coil condenser shell | 8 ft |

Table 1: Helical Coil Design Specifications

**Trial Run #1:** Trial was conducted bypassing the main condenser and driving all the water vapor through a new condenser recovering the water condensate in a drum located in the utilities room.

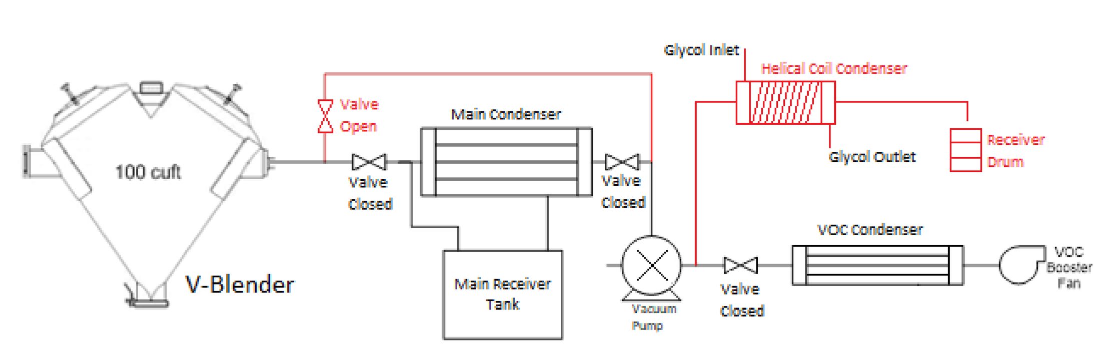



Figure 3: V-blender Ventilation System Schematic Trail Run #1

## Tests and Results (Cont.)

**Trial Run #2:** Trial was conducted using main condenser with the shutoff valve half cranked to limit the amount of glycol to limit the condenser capacity and avoid freezing the water. Screen filter was placed over the ventilation discharge of the new receiver drum to control the fugitive product dust.

**Trial Run #3:** Screen filter was removed and vacuum connection from central dust collector was placed over the ventilation discharge of the new receiver drum.

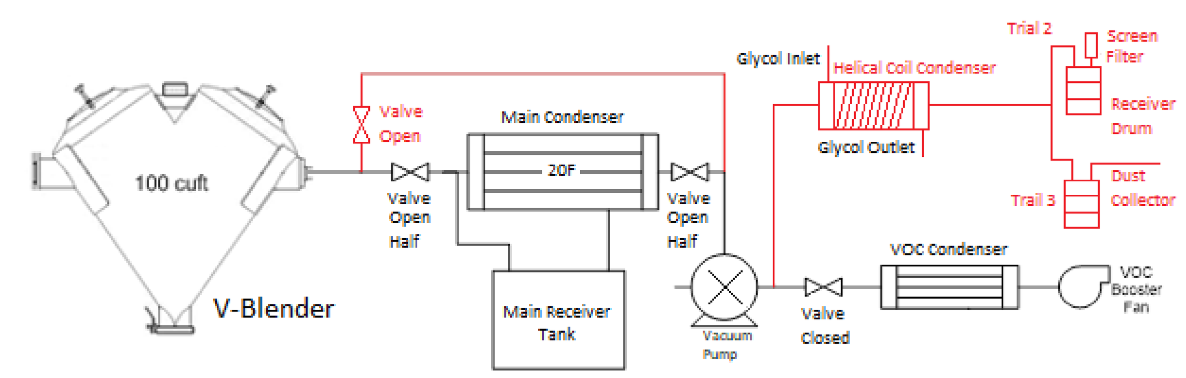



Figure 4: V-blender Ventilation System Schematic Trails #2 & #3

**Trial Run #4:** New condenser was eliminated because the water passing through the vacuum pump affects the pump performance, and pass all the water vapor through the main condenser and connect the ventilation directly to the vacuum dust collector.

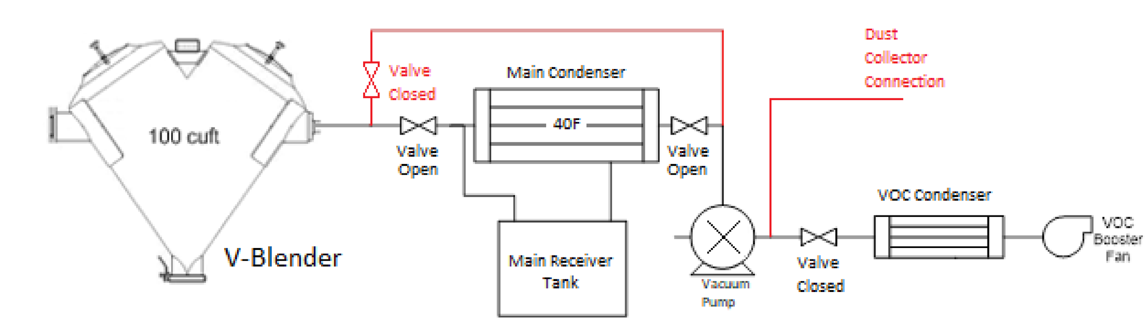



Figure 5: V-blender Ventilation System Schematic Trail Run #4

**Trial Run #5:** Free suspended hood was designed using equation $Q = V_h\, (10X^2 + A_h)$ to handle a volumetric flow rate of 442 CFM [2]. Vacuum dust collector suction was separate from the new receiver vent and free suspended hood housing was installed.

**Trial Run #6:** HEPA Filter station [3] was selected based in the actual volume flow rate installed instead the suspended hood.

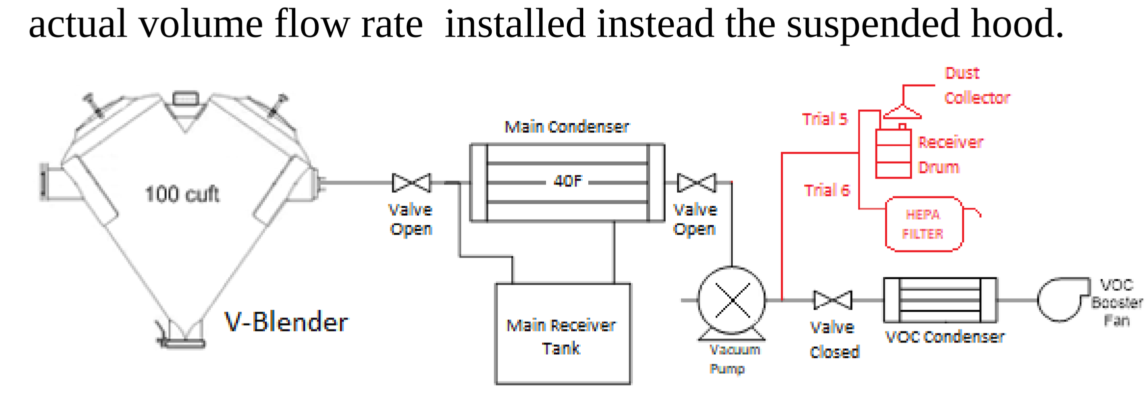



Figure 6: V-blender Ventilation System Schematic Trails #5 & #6

Mass Balance and Energy Balance of the Condenser for Trials 5 and 6 was calculated.

**Mass Balance** for a condenser is:

**Mass In = Mass Out** = 4.83 Gallons per Hour

**Energy Balance** for a condenser is the cooling rate:

$Q = M*\Delta H$ *where* H = Enthalpy

$Q = -42{,}850.59$ Btu/Hr (Average)

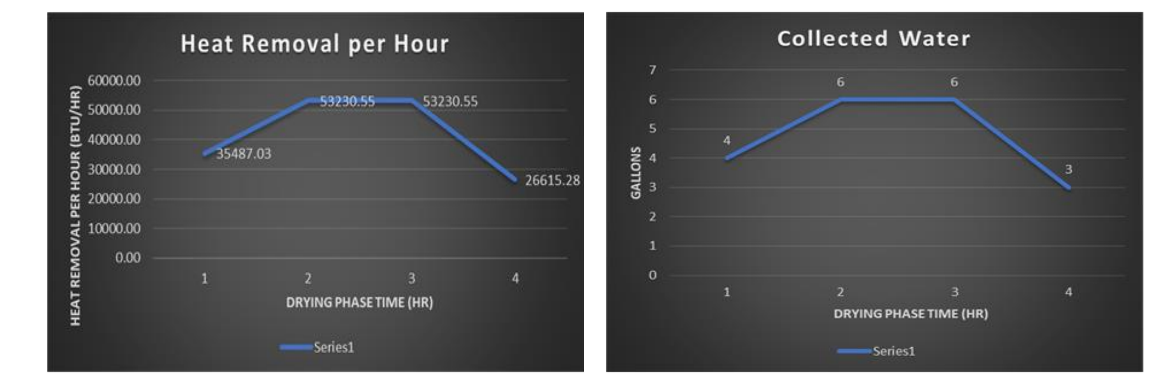
**Condenser Efficiency** (Based in the collected water versus the added water to the mix)

$\eta_{condenser}$ = 19 gal/19.3 gal = **98%**

## Conclusions

The condenser heat transfer analysis show that was capable to keep an average cooling rate of 42,850 Btu/Hr during the drying phase of the process.

Condenser had an efficiency of 98% based in the collected water versus the added water to the product mix.




Graphs: Heat Removal per Hour and Collected Water in the Process

Suspended hood and HEPA filter, independently, were capable to handle a Volumetric Flow Rate of 442 CFM generated by the system and control the product dust.

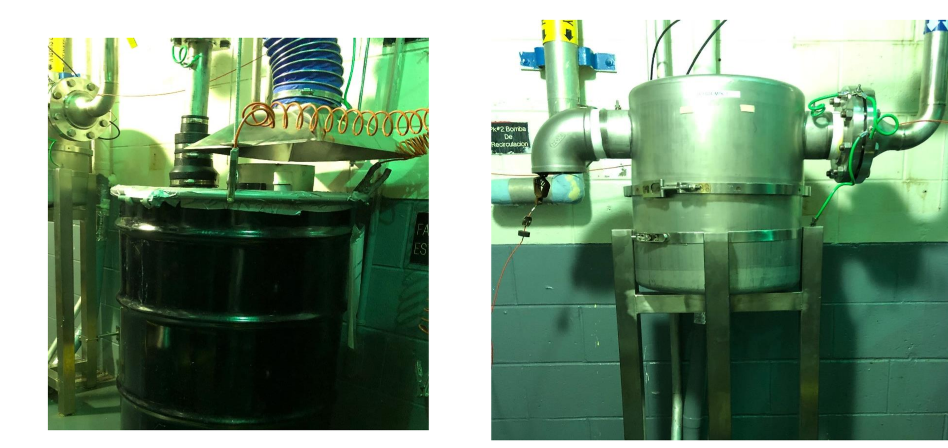


Figure 7: Suspended Hood and HEPA Filter Station

The improvements performed to the ventilation system of the Patterson Kelly V-Blender solves the stated problem under this study. Also, gives the flexibility of the system of run water-based product and solvent based product with a minimum change between the product lots.

## Acknowledgements

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## References

[1] Giacomo Bonafoni and Roberto Capata, "Proposed Design Procedure of a Helical Coil Heat Exchanger for an Orc Energy Recovery System for Vehicular application", Submitted on 13April 2016.

[2] John R. Richards, Ph.D., P.E. and Air Control Techniques, P.C.,"Control of Particle Matter Emissions", US Environmental Protection Agency, Student Manual, APTI Course 413, Third Edition, January 2000

[3] Solberg Manufacturer Inc., "Inlet Vacuum Filters", Available: https://www.solbergmfg.com