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Oxygen Removal from the White Wine in Winery

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Abstract

The presence of oxygen in the reductive technology of the wine production has very detrimental effect particularly on the quality of white wines. Oxygen dissolves in wine mainly during its manipulation (filtration, transfer, bottling) but also during its storage. In our work we focused on the influence of nitrogen flowrate on the removal of oxygen from white wine in real technological conditions of winery. Concentration of oxygen dissolved in wine was measured by an oxoluminescence method using NOMA Sense O2/P300 analyzer. Nitrogen flowrate was mechanically regulated by the valve on the pipeline and measured by electronic flow detector. The removal of oxygen from white wine by injection of nitrogen during the transport of white wine was studied. It was shown that oxygen concentration in wine should be diminished from 2,6 mg.l^{-1} to lower than 0,6mg.l^{-1} at flow rate of wine 26 m^3.h^{-1}. The maximum of nitrogen flow rate was 5 Nm^3.h^{-1}.

Keywords: *Wine, Wine transport, Oxygen removal*

Introduction

The presence of oxygen in the reductive technology of the wine production has very detrimental effect particularly on the quality of white wines. The oxidation of wine is primarily prevented by sulfur dioxide treatment either of the grape juice or the treatment of the finished wine. Currently there is the trend to lower the concentration of sulfur dioxide in wine. There is an effort to develop alternative methods to prevent dissolving of oxygen or even to decrease its concentration in wine. Oxygen dissolves in wine mainly during its manipulation (filtration, transfer, bottling) but also during its storage. Wine storage tanks are often not completely filled and the wine is in contact with air. The problem is solved by injection of inert gas into not completely filled tank. However the air gets back in after some time if this is not done properly. All operations in the modern wine-making technologies are performed in the atmosphere of inert gases. Nitrogen, argon and carbon dioxide or their mixtures are preferred. Carbon dioxide is soluble in white wines (107l.hl^{-1} at 20°C). Therefore, it is not recommended for use in partially unfilled tanks. Practical use of argon is limited by its high price. Nitrogen is the most frequently used inert gas, which is easily obtained from the air by pressure swing adsorption.

Oxygen generally decreases quality of wine in particular at the end of fermentation, during its storage and during its bottling. The concentration of oxygen dissolved in wine could be 6-9 mg.l^{-1}, depending on its temperature. Before the bottling the content of oxygen in wine should not be above 0,6 mg.l^{-1} [1,2]. Oxygen can be removed from the wine before bottling by injection of dispersed nitrogen into the pipeline used to transfer the wine to the bottling machine. When flow of the wine is passing the distributor of inert gas the bubbles of inert gas enter the wine and drag-out dissolved oxygen. Temperature of the wine is important this process. Overall efficiency of this process depends on several factors, including [3-5]:

- Size of the bubbles of used inert gas
- Duration of the contact of inert gas and wine
- Temperature of wine
- Pressure of inert gas
- Number of operations
- Ratio of inert gas flowrate to wine flowrate
- Initial amount of oxygen in wine
- Design of the whole winemaking facility

In our work we focused on the influence of nitrogen flowrate on the removal of oxygen from white wine in real technological conditions of winery.

Materials and Methods

The composition of the Riesling wine used in measurements is shown in TABLE 1.

TABLE 1. **Composition of Riesling wine**

alcohol, %	11,5
acids, $g.l^{-1}$	6,1
sugar, $g.l^{-1}$	3,6
free SO_2, $mg.l^{-1}$	31
bound SO_2, $mg.l^{-1}$	126

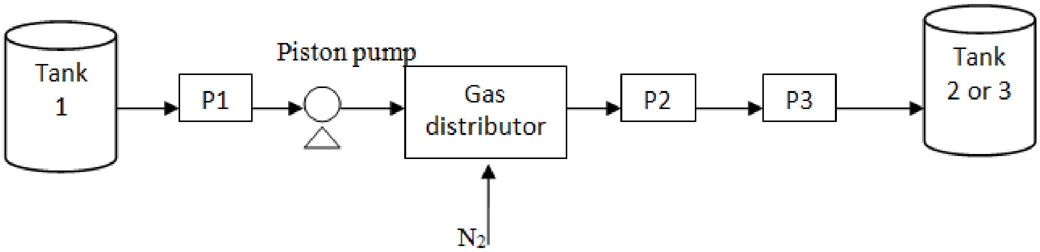
Concentration of oxygen dissolved in wine was measured by an oxoluminescence method using NOMA Sense O2/P300 analyzer. The analyzer was equipped with the temperature detector and a barometer for compensation of temperature and pressure. The immersion detector allowed measurement of oxygen concentration in tanks with stored wine either in wine or in the atmosphere above it in case the tank was not completely filled with wine.

Measurements were done in a cellar of the winery where temperature was kept at 11°C. Therefore temperature of the wine stored for a long time in stainless steel tanks was close to this value. The wine was transferred from the completely full tank 1 to empty tanks 2 and 3. The volume of each tank is shown in TABLE 2. The temperature of nitrogen used in measurements was also 11°C and nitrogen was transferred via tubing under the pressure of 6 bar. The nitrogen was generated from air using pressure swing adsorption generator in the purity of 99,9%. Wine was pumped from tank 1 to tanks 2 and 3 by the piston pump. Wine was pumped into tank 2 at two different flowrates. The content of the tank 1 was stirred before the transport to equilibrate the concentration of oxygen in the whole volume of the tank. Nitrogen flowrate was mechanically regulated by the valve on the pipeline and measured by electronic flow detector.

TABLE 2. **Volumes of the tanks**

	Tank 1	Tank 2	Tank 3
Volume, l	40 000	10 000	10 000

FIG.1. **Instrumentation diagram**



After the pump was switched on the values of dissolved oxygen were measured at the zero nitrogen flow FIG. 1. Subsequently the nitrogen flowrate was set to $2Nm^3.h^{-1}$ (normal cubic meters per hour) and the concentration of oxygen was recorded. Injection of nitrogen directly into the wine flow was done by the gas distributor with the porosity of 5 µm (FIG. 2). The distributor was placed directly in the outlet of the pump. Three visors with sensors used in experiments were measurement points for the oxygen dissolved in wine. (FIG. 3). First visor (P1) was placed at the pump intake 3,5 m far from outlet of tank 1. Second visor (P2) was 4 m far from nitrogen distributor. Third visor (P3) was placed in the inlet of tank 2 or 3 respectively, 34 m far from second visor.

FIG.2. **Visor**

FIG.3. **Gas distributor**

Results

Results of the measurements for the wine flow rate of 12,6 $m^3.h^{-1}$ are displayed in FIG. 4.

FIG. 4. **Change of oxygen concentration in wine at flow rate 12,6 $m^3.h^{-1}$ with growing flow rate of injected nitrogen measured in the visors P1, P2 and P3.**

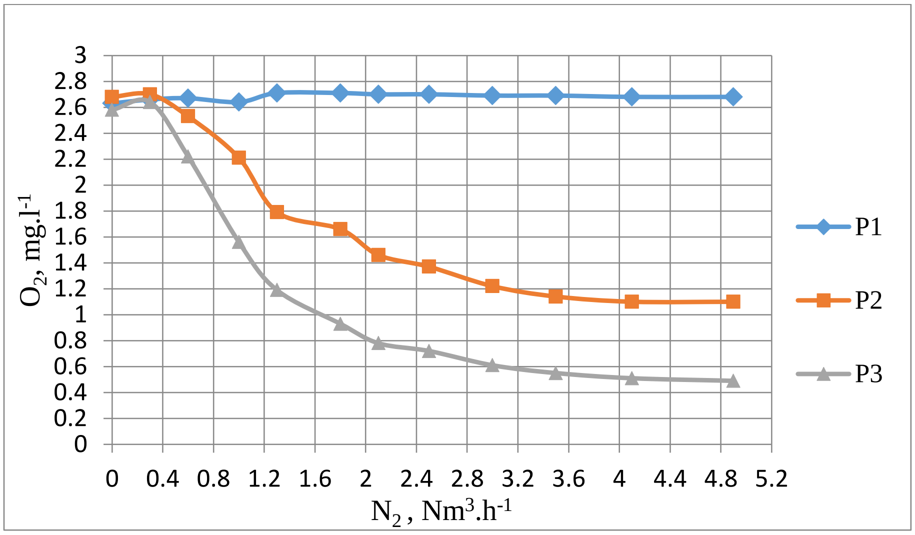
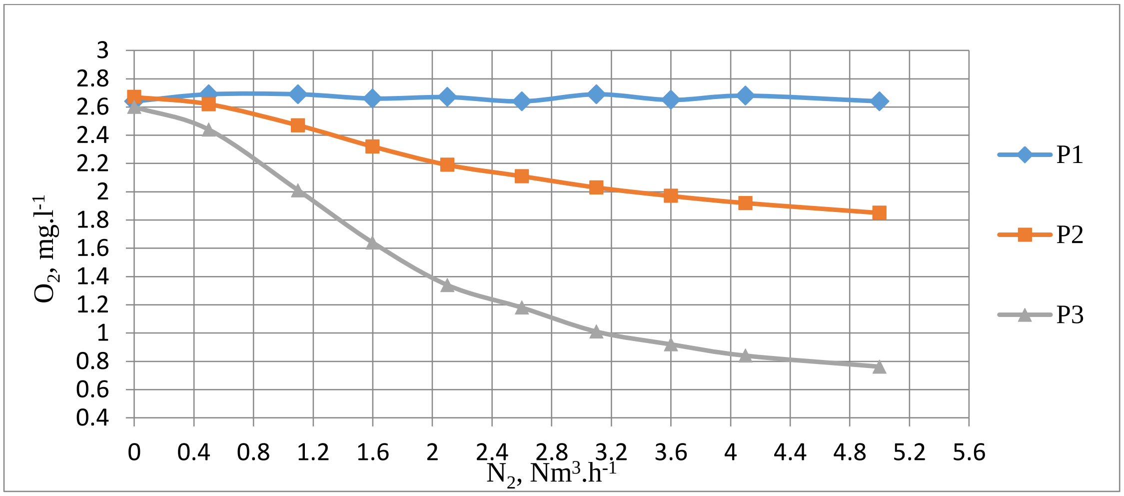


FIG. 4 shows that the biggest change of oxygen concentration is at the flowrate of nitrogen up to 1,3 $Nm^3.h^{-1}$. Further increase of the nitrogen flow rate causes slower decrease of the oxygen concentration in wine. When flowrate of nitrogen reached 4 $m^3.h^{-1}$ further increase in the nitrogen flowrate does not change the concentration of the oxygen in wine, which remains 1,1 $mg.l^{-1}$. We assume that in 4 m of length of the pipeline from the nitrogen gas injection through the gas distributor and the nitrogen gas flow-rate of 4 $Nm^3.h^{-1}$ the oxygen concentration can drop from 2,7 $mg.l^{-1}$ to 1,1 $mg.l^{-1}$ at 11°C. Hence the drop of oxygen concentration after 4 m of pipeline corresponds approximately to 1,6 $mg.l^{-1}$ O_2.

The change of the concentration of the dissolved oxygen depending on the nitrogen flowrate measured on the visor P3 is also shown in FIG. 5. Visor P3 was situated on the inlet to the tank 2 and its distance from the injection of the nitrogen gas into the pipeline with the flowing wine was 38 m.

The above facts point out that the concentration of the oxygen dissolved in wine is influenced both by changing the flow-rate of nitrogen and by the length of pipeline. That implies that time of contact of the phases, in this case of the gaseous nitrogen with wine, also plays important role. With this nitrogen flow-rate and the above conditions it is possible to obtain concentrations of the oxygen dissolved in wine lower than 0,6 $mg.l^{-1}$.

FIG. 5. **Change of oxygen concentration in the wine at flow rate 26,3 $m^3.h^{-1}$ with the growing flowrate of the injected nitrogen. Measured in the visors P1,P2 and p3.**



The pipeline length to the visors P2 and P3 remained unchanged as well as the other conditions except the wine flowrate which was roughly doubled to 26,3 $m^3.h^{-1}$. This resulted in the less sharp drop in the concentration of the dissolved oxygen, which can be attributed to the increase of the wine flow rate in the pipeline. The increase changed the ratio of the nitrogen flow to the wine flow in the pipeline. The change of this ratio has the influence on the efficiency of the oxygen removal, as was already reported in the literature [6].

FIG. 6 compares the changing values of the dissolved oxygen with the growing flowrate of the injected nitrogen into the wine flowing at 12,6 $m^3.h^{-1}$ and 26,3 $m^3.h^{-1}$ as recorded in the visor P2. Similarly in FIG. 7. compares the same values as recorded under the same conditions in the visor P3. The difference of the lowest obtained values of the dissolved oxygen in two different flowrates of wine is approximately 0,7 mg.l^{-1} in the visor P2 and approximately 0,3 mg.l^{-1} in the visor P3. It clearly shows that in the distance of 4 m the time for the interaction of the nitrogen gas with the wine is too short to remove oxygen efficiently.

FIG.6. **Comparison of oxygen concentration at the different flowrates of wine in the visor P2.**

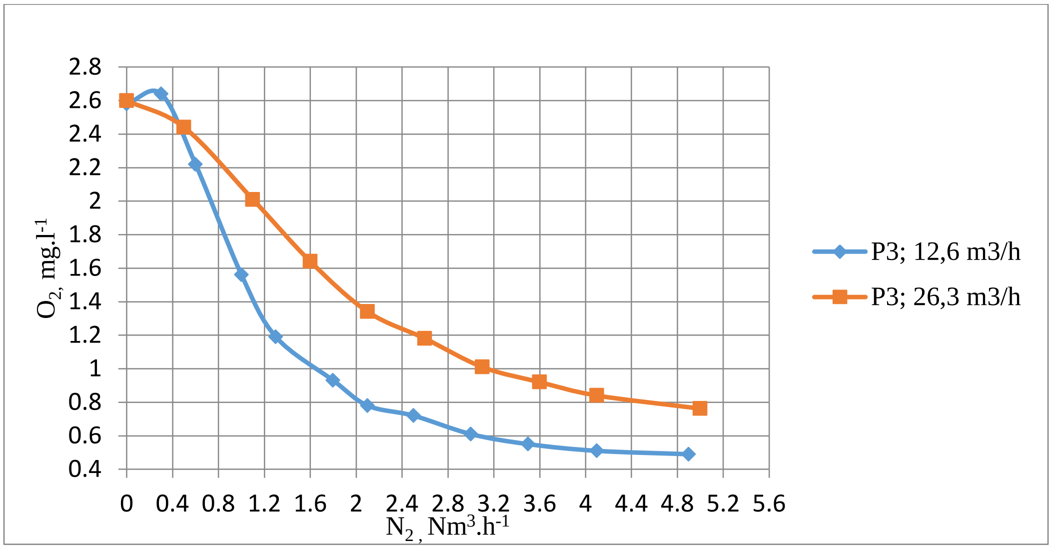
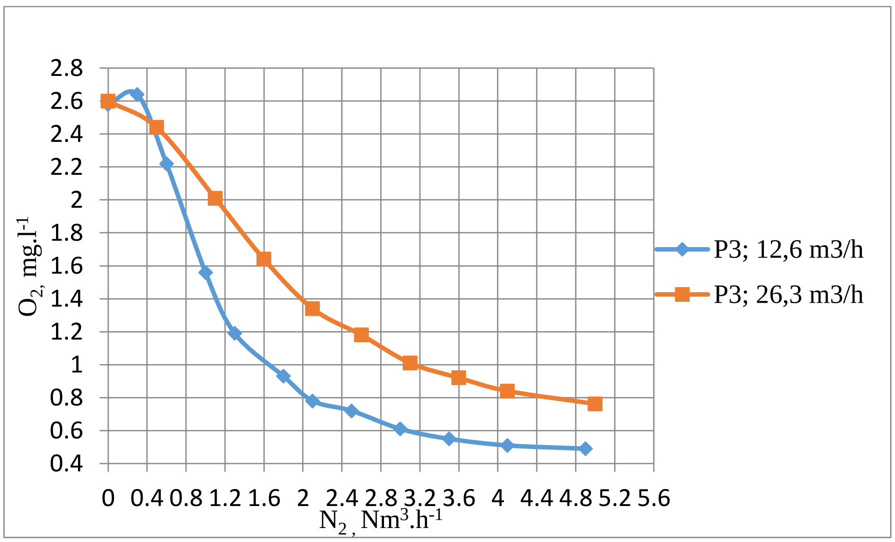


FIG.7. **Comparison of oxygen concentration at different flow rates of wine in the visor P3.**



Conclusion

The removal of oxygen from white wine by injection of nitrogen during the transport of wine was studied. It was shown that oxygen concentration in wine should be diminished from 2,6 mg.l^{-1} to lower than 0,6mg.l^{-1} at flow rate of wine 26 m^3.h^{-1}. The maximum of nitrogen flow rate was 5 Nm^3.h^{-1}.

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