# AN INNOVATIVE METHOD FOR A FASTER REMUAGE OPERATION

**Roberto Beghi, Valentina Giovenzana, Simone Marai, Enrico Ferrari, Riccardo Guidetti**
(1)Department of Agricultural and Environmental Sciences - Production, Landscape, Agroenergy, Università degli Studi di Milano, via Celoria 2, 20133 Milano, Italy.
roberto.beghi@unimi.it

## Introduction

Methods for sparkling wine production include the "classic method" (or method champenoise). According to the "classic method", after an initial fermentation the wine is fermented again in the bottle by adding selected sugars and yeasts (liqueur de tirage). The wine will thus acquire its typical pressure, visible in the form of small bubbles, caused by the carbon dioxide produced by the second fermentation ("refermentation") occurring in the bottle.

After a rest period for in-bottle fermentation, which will take at least 12/15 months, the remuage process is carried out. The word remuage derives from French ("riddling" in English), and relates to preparing the bottle for removal of wine deposits. According to the most traditional techniques, the bottles are arranged on special racks (called pupitres), where the bottle is positioned with the neck lower than the bottom; the bottle is continuously rotated by hand on the support in order to cause the lees of dead yeast to deposit onto the cap. Traditionally, the remuage phase lasts about 30 days. The last processing step, called dégorgement, is then carried out, wherein the wine contained in the bottle neck is frozen and the cap is removed to let the deposit come out under pressure. The bottle is then typically topped up with (aged) wine syrup and sugar (liqueur d'expedition); the amount of sugar introduced will determine the characteristics of the sparkling wine, ranging from demi-sec to extra-brut. At this point, the sparkling wine bottle is corked with the traditional mushroom-shaped cork, and a wire cage is added to prevent the cork from coming out because of the pressure developing inside the bottle.

Nowadays, the remuage process is carried out using machines called gyropalettes. In modern wineries, the remuage process is carried out using automated riddling machines. These machines are a partial solution to the problem of the labour costs incurred for moving the bottles; however, they require a high initial investment, while the remuage process will last about 7 days. A winery using these methods might not be able to meet a suddenly increasing demand for bottles, due to long waiting times. Therefore, it is desirable to reduce the duration of the remuage phase. A few solutions are known in literature aiming at shortening the duration of the remuage process.

A research carried out by the Department of Agricultural and Environmental Sciences - Production, Landscape, Agroenergy of the Università degli Studi di Milano aims at providing an innovative remuage method which is alternative to the available solutions. The study proposes the use of ultrasonic vibration to be induced in the bottles via a direct mechanical coupling, so as to be able to speed up the remuage operation.

## Experimental activity

A general idea at the basis of the research is to provide a remuage apparatus comprising a support element configured to hold one or more bottles in at least one tilted position with respect to the vertical; the apparatus is designed to induce a mechanical vibration at ultrasonic frequencies in the bottle.

Ultrasound generates vibrations in the bottles, which cause the lees to slide faster along the natural slopes of the glass of the tilted bottle. The combination of ultrasound and bottle inclination will cause the lees to accumulate quickly in the neck of the bottle, thus speeding up the remuage phase.

## Experimental apparatus for ultrasonic remuage

The experimental remuage apparatus comprises a support element configured to hold one bottle in at least one tilted position with respect to the vertical, and comprises one vibrating element configured to be mechanically coupled with the bottle. Figure 1 schematically shows a first embodiment of the experimental ultrasonic remuage apparatus. The vibrating element is positioned to induce a mechanical vibration at ultrasonic frequencies in the bottle. In the present description, "tilted position" will refer to any position in which the bottle is not upright or vertical; a "vertical" bottle is a bottle the bottom of which lies on a flat surface, i.e. the typical position of an open bottle resting on a table. For example, a bottle lying on its side or overturned with the (sealed) cork down, or in the position shown in Figure 1, is in a "tilted position".
The apparatus is configured to maintain a rigid mechanical coupling between the vibrating element and the bottle, in order to transmit the vibration at ultrasonic frequencies to the bottle.
The vibrating element comprises one axial transducer with ultrasonic vibration, configured to stress the bottle in an axial direction with respect to the longitudinal axis.
Also a tangential transducer with ultrasonic vibration was tested to stress the bottle in a tangential direction with respect to the circular section of the bottle sidewall.
The experimental apparatus is equipped of a control system adapted to operate vibration according to predetermined time intervals and/or at a predetermined oscillation frequency.
The apparatus also comprises a rotation system to change the inclination of the bottle over time with respect to the vertical.
A second control system allows to periodically change the bottle inclination according to a predetermined time law.

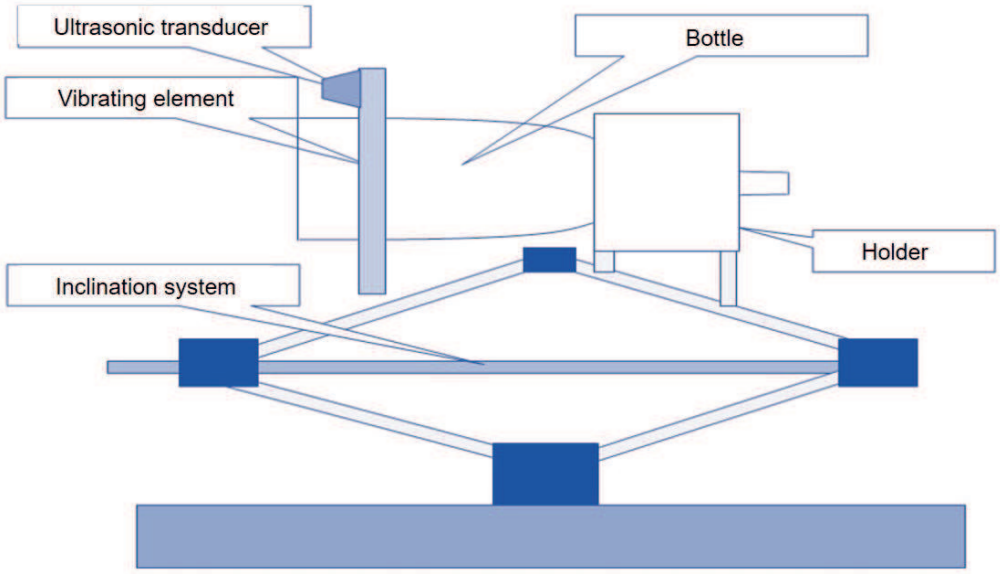


*Figure 1. Experimental setup scheme*

The holder element consists of a passive support structure that allows to support the bottle in a tilted position facing downwards just like the pupitre of the classic method. The holder is preferably provided by a suitably sized hollow cylinder into which the bottle which is inserted therein from the neck with the cork facing downwards, fits simply by friction.

The vibrating element represents the active part of the apparatus. In the example, the vibrating element comprises one piezoelectric transducers, which induce an ultrasonic mechanical vibration in the bottle through a coupling flange.

The coupling flange preferably consists of two semi-circular bodies which can be screwed to each other, and which embrace the body of the bottle. On the flange, a few housings are formed for fitting the transducers with different orientations, thus ensuring that the vibrations will be applied along different directions, as will be further explained below.

The transducer comprises two rings of piezoelectric material overlapped and tightened to each other, since they are preloaded by two metal plates. When electric voltage is applied to the transducer, the ring will react by becoming mechanically deformed and oscillating at a very high frequency with micrometric movements, thus producing ultrasonic waves. The coupling flange comprises an aluminium ring cut into two semi-circular halves that can be re-screwed to each other, thus taking again the original shape and embracing the cylindrical body of the bottle. The housings having different orientations are formed on the flange to allow fitting the transducer (by means of suitable hardware) and applying vibrations along different directions with respect to the bottle axis.

The remuage apparatus allows, therefore, positioning a bottle onto the support element in at least one tilted position with respect to the vertical, and inducing a mechanical vibration at ultrasonic frequencies in the bottle via the vibrating element mechanically coupled thereto.
In the embodiment shown in Figure 1, the vibration means comprise, in a preferred embodiment, a transducer with ultrasonic vibration, which is configured to stress the bottle in an axial direction with respect to the longitudinal axis of the same.

In an alternative embodiment (not shown), further or different ultrasonic vibration transducers are employed.

It is desirable to combine the mechanical vibration with a gradual increase in the inclination of the bottle in the overturning direction, so as to promote the accumulation of the residues in the neck of the bottle, thus improving the remuage.

The apparatus of this study is particularly suitable for use at experimentation level, for verifying the effect of different angles of inclination of the bottle and different times and modes of application of the vibration, in order to find out the optimal remuage conditions.

## Experimental method and results

The experimental method for remuage comprises the steps of (i) positioning the bottle onto the support element in at least one tilted position with respect to the vertical, and (ii) inducing a mechanical vibration at ultrasonic frequencies by means of a vibrating element mechanically coupled.

The mechanical vibration is generated at predetermined time intervals and/or at a predetermined oscillation frequency, preferably comprised between 20 and 50 kHz. The bottle inclination with respect to the vertical is changed over time and it is combined with a gradual increase in the inclination of the bottle in the overturning direction.

By using a knob, the operator can set the (ultrasonic) oscillation frequency of the vibration, when this option is made available by special adjustable transducers. Preferably, the predetermined oscillation frequency is comprised between 20 and 50 kHz, more preferably comprised between 25 and 30 kHz or between 35 and 45 kHz. Commercial transducers with vibration frequencies of 28 kHz or 40 kHz may be used.

The preliminary experimental tests conducted have shown that the present invention ensures a much shorter remuage time. The traditional remuage method using pupitres takes about 30 days; the more modern remuage method on gyropalette takes about 7 days; the results obtained by the experimental remuage apparatus showed a completion of the remuage process in approximately 4 hours (Figure 2).

The results were encouraging and resulted in a European patent (Remuage apparatus and method, EP 3078734 A1).

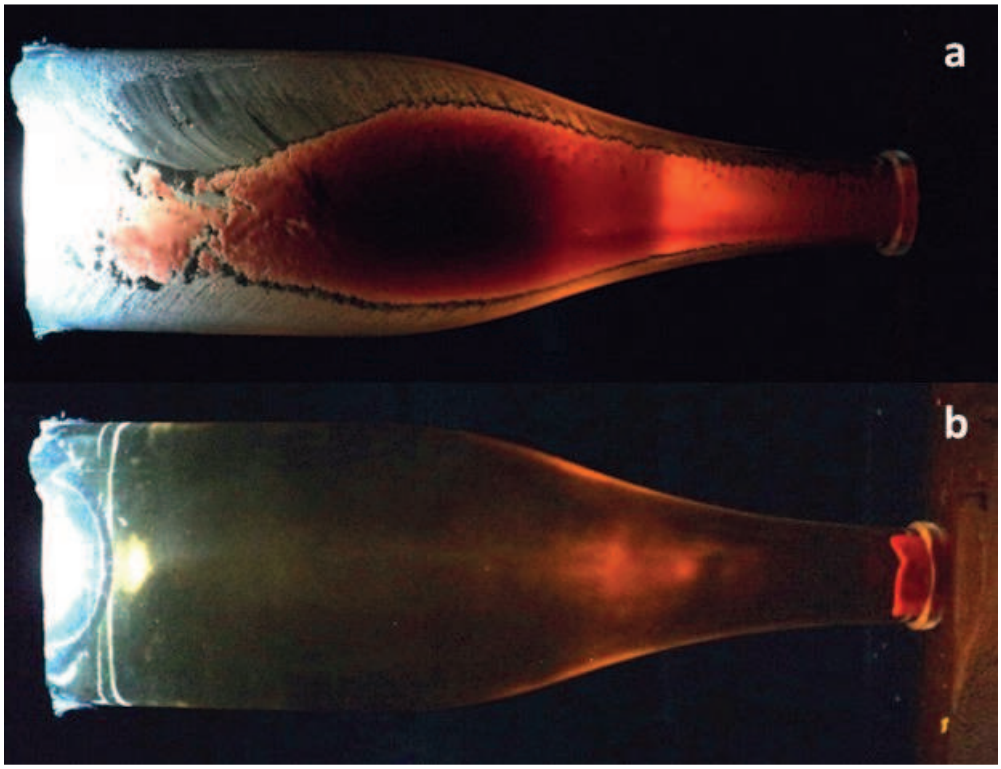


*Figure 2. Examples of images taken in a darkroom to evaluate the effect of treatment: before (a) and after (b) treatment with ultrasonic vibrations*

## Conclusions and future perspectives

The final objective of the work is to provide a remuage apparatus and a remuage method wherein the duration of the treatment is reduced, allowing the treatment of one or different batches of bottles, resulting in an advantageous and effective solution in improving sparkling wine production and which are attractive for wineries (e.g. to develop a kit for converting existing riddling machine).

It is a further object of the work to provide a remuage apparatus and a remuage method that will allow treating one or more bottles simultaneously.

A further general idea at the basis of the research is to provide a kit for converting a gyropalette machine, including at least one support element configured to hold bottles in a tilted position with respect to the vertical; with this kit, which is applicable to existing gyropalette machines, a vibrating element will be mechanically associated with the gyropalette machine. This conversion kit allows, therefore, transforming gyropalette machines into remuage apparatus according to the present research, to improve the efficacy and speed of the remuage treatment. At the same time, this conversion kit allows to work using existing gyropalette machines without incurring in higher costs for purchasing new machinery. This solution is particularly suitable for industrial use, i.e. for use in a winery where a remuage treatment must be carried out on many bottles.

The structure of the envisaged apparatus is similar to that of a gyropalette machine, improved in accordance with the present study (Figure 3). The remuage apparatus comprises a support element configured to hold a plurality of bottles in tilted position, as obtainable with traditional gyropalette machines. The apparatus further comprises a multi-bottle vibrating plate, on which a plurality of vibrating transducers is applied. The vibrating plate is mechanically coupled with the bottles, and the vibrating transducers are adapted to induce a mechanical vibration at ultrasonic frequencies in the bottles. By means of the tie rods, which ensure a rigid interface between the bottles and the vibrating plate, a system is created for transmitting the ultrasonic mechanical vibration to the bottles. In the preferred embodiment of the apparatus, the vibrating transducers are configured to stress the bottles mainly in the axial direction with respect to the longitudinal axis of the bottles themselves.

Just like traditional gyropalette machines, the envisaged apparatus further comprises rotation means configured to change the inclination of the bottles with respect to the vertical over time, by rotating the basket, preferably using electric motors (not shown).

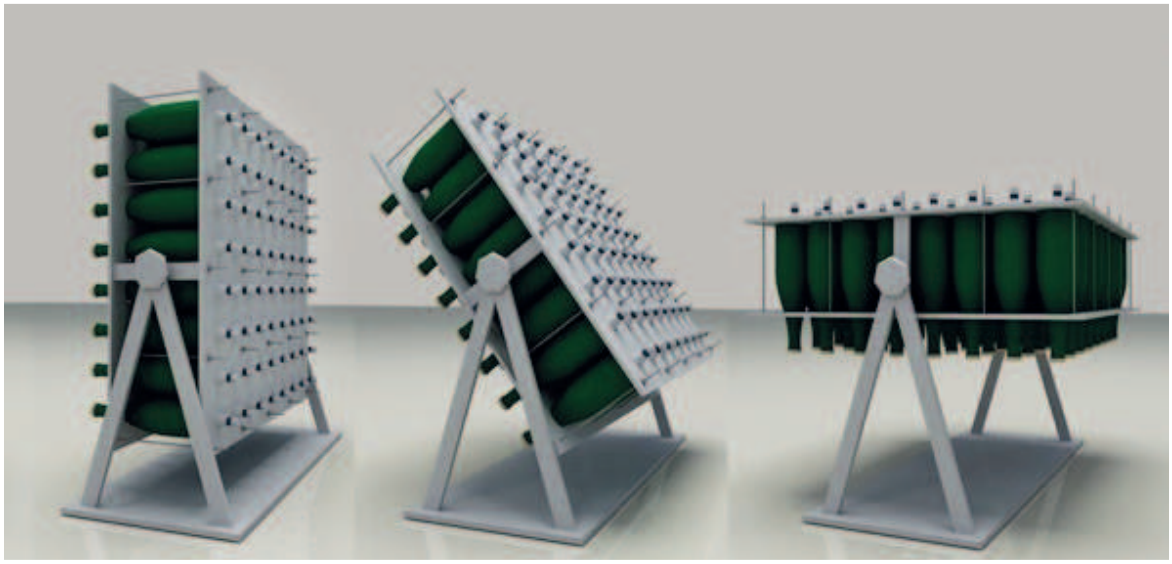

*Figure 3. Rendering of a possible solution for the application of piezoelectric transducers on many bottles*

***Abstract***

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