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Statistical tools applied for the reduction of the defect rate of coffee degassing valves

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ABSTRACT

Coffee is a very common beverage exported all over the world: just after roasting, coffee beans are packed in plastic or paper bags, which then experience long transfers with long storage times. Fresh roasted coffee emits large amounts of CO_2 for several weeks. This gas must be gradually released, to prevent package over-inflation and to preserve aroma, moreover beans must be protected from oxygen coming from outside. Therefore, one-way degassing valves are applied to each package: their correct functionality is strictly related to the interference coupling between their bodies and covers and to the correct assembly of the other involved parts. This work takes inspiration from an industrial problem: a company that assembles valve components, supplied by different manufacturers, observed a high level of defect rate, affecting its valve production. An integrated approach, consisting in the adoption of quality charts, in an experimental campaign for the dimensional analysis of the mating parts and in the statistical processing of the data, was necessary to tackle the question. In particular, a simple statistical tool was made available to predict the defect rate and to individuate the best strategy for its reduction. The outcome was that requiring a strict protocol, regarding the combinations of parts from different manufacturers for assembly, would have been almost ineffective. Conversely, this study led to the individuation of the weak point in the manufacturing process of the mating components and to the suggestion of a slight improvement to be performed, with the final result of a significant (one order of magnitude) decrease of the defect rate.

1. Introduction

Coffee is nowadays a very common beverage all over the world. The best way to taste it is to have it prepared from freshly roasted beans. Trade is usually conducted by Multinational companies that export coffee in many countries all over the world. Just after roasting, coffee beans are packed in plastic or paper bags. Afterwards, the procedure for exporting is started, involving very long transfers and long storage times (before departure, passing the border, upon arrival). Coffee beans may generally be conserved even for a long time, but three important issues must be considered [1]. Fresh roasted coffee beans are responsible of the emission of large amounts of gas (CO_2): this process starts just after roasting and may last for up to several weeks. Retaining these gases inside the package may be dangerous, as it may cause package inflation with

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consequent failure. Moreover, inflated packages may also roll over the shelf and then drop down to the floor. The second issue is related to the importance of preventing the escape of the high molecular weight gases, constituting the product's aroma [2]. The final issue to be considered is that coffee requires protection from oxygen to maintain its fresh roasted taste. Oxygen has a chemical reaction with the volatile flavors in fresh roasted coffee, causing its quick degradation. Therefore, it is important to warrant an efficient sealing from the external environment, to prevent oxygen flow toward the coffee beans

In order to meet the aforementioned requirements, coffee one-way degassing valves were developed and introduced into market. Nowadays, they are largely produced: their function is to preserve roasted coffee flavor before its consumption: some images are shown in Fig. 1. Their important role at warranting the high quality and taste of coffee beverages, along with their chemical properties to be conserved during storage, is emphasized in some recent studies [3,4]. The valve consists of a body, directly attached to the package, and supporting a rubber disk and a filter.

Their functions are respectively to provide an oxygen-proof seal and to prevent small particles from clogging the one-way valve. They are finally fixed by a plastic cover with a small hole for air exhausting. A scheme of the valve is shown in Fig. 2(a), along with details regarding the coupling dimension of the valve body and the cover in Fig. 2(b). The connection between the two parts is theoretically warranted by the interference between the inner cylindrical surface of the body and the external one of the cover. In [1] it is reported that many roasters are experiencing an unacceptable oxygen exposure, with consequent degradation of the product. Every single valve has a very low economic value (less than 1 $), however a widespread malfunctioning may lead to a significant economic loss, due to poor quality of the traded coffee. Despite the serious outcomes from not conformal or failing degassing valves, to the best of the author's knowledge, this issue has never been tackled in literature. In particular the typical tools of statistics and reliability have never been applied as a rigorous approach to control the defect rate. This occurrence is the main motivation of this research.

The present paper takes inspiration from an industrial case study. A company that manufactures coffee valves, assembling components from different suppliers, observed a high defect rate, considering own quality control and after sales costumer remarks. The defect rate was around 4%, considering a year production of over 200,000 valves.

The aims of this study can be summarized in the points below:

Fig. 1. Coffee valves (a) just after assembly and (b) upon their application to the package.

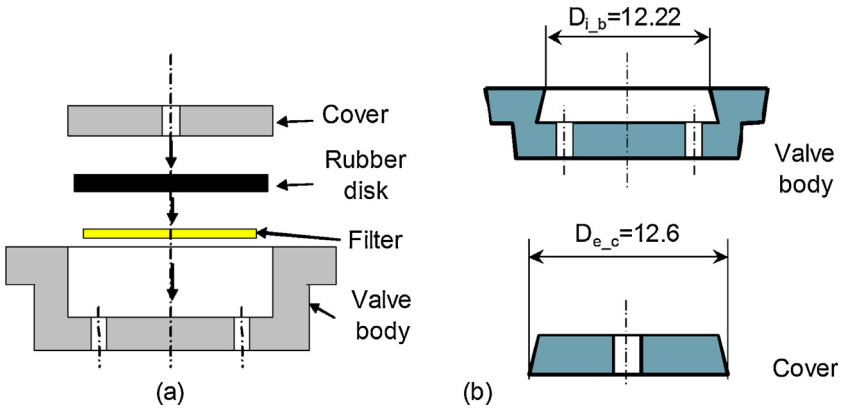

Fig. 2. (a) General scheme of the valve, (b) sketches of the valve body and of the cover with related coupling dimensions (dimensions in mm).