CAD Modeling and simulation of a semi-automatic machine for olive oil packaging

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Abstract

Purpose:

Starting from the end-user requests, this document describes the development of a new product, a filling machine. The aim was to design a simple and economic machine, able to provide the user with a semi-automatic device to fill small containers of different sizes and materials, with a discrete productivity and lower operating costs.

Method:

By identifying the needs of the industry and analysing the technical problems, the specifications of the new machine were defined. Then, with the use of CAD/CAE techniques, several solutions were evaluated. Moreover, during the initial phase of conceptual design, we used the deductive technique: analysing similar problems, innovative or improved solutions compare to the traditional ones have been proposed.

Result:

A new product characterized by innovative solutions was designed.

Discussion & Conclusion:

The use of the CAD/CAE techniques allowed to develop and to analyse in a very short time different solutions before defining the final product. The use of a weight filling system allows to fill containers of different shape, volume and material. The rapidity of the set-up of the machine and the absence of stagnation points of the product, combined with the small dimensions and weight of the machine itself, make it mobile and suitable to fill even with small quantities of different products.

1 Introduction

The trend in the demand of olive oil in the various consuming countries indicates a substantial stability of the traditional markets (Spain, Italy and Greece), while there has been a marked and consistant increase in demand on behalf of “new consumer” countries [1].

Nowadays the consumer that is more aware and has a greater spending power requires a higher quality with a safe and controlled origin, characteristics which are essentially integrated with each other and contained in the concept of traceability. The product flow is accompanied by the flow of information regarding the product itself in each stage of the supply chain (agriculture, food industry) down to the end-user.

Over the last few years we have seen a concentration of the oil industry in all UE member producing countries: however, there is a noticeable difference between Spain, the leading country, where we find large co-operative societies that take care of the extraction and bottling of the olive oil of its members and, on the other side, Italy and Greece, where we find a large number of small oil-mills close to the collecting points.

The large packaging industry is characterized by an oligopoly of companies that bottle large quantities of olive and seed oil and transform a product of average or poor and largely undifferentiated quality, in order to meet the internal large distribution market. These companies often produce for dozens of labels: in the case of large Italian packaging factories, they have been acquired by foreign companies which subsequently used them to input into the market large quantities of mixtures of oil obtained from olives from the Community, Tunisia and other countries, or worse, they have been the carriers used to export to the world refined oil blends, labelled as "Made in Italy" oil [2].

In order to contrast fraud and deception, since 2008 all bottlers are obliged to label the origin of the olives used to make the olive and extra virgin olive oil [3].

This obligation, of national character, was initially opposed by the EU because it was in clear conflict with European legislation that promoted the "Community" product. Italian efforts to change the legislation on oil traceability lead to a modification of the European standard [4].

The "transparent" labelling obligation as of July 1, 2009, has been translated into a regulation that allows EU countries to ban the production of mixtures of foreign oil to be sold in its own territory, but does not ban the sale on its territory of oil produced in other countries, nor the production of mixtures for export purposes. The regulation, however, allows the designation of origin of the EU member country, as well as that of European community. The above considerations lead to expect a future increase in the market of the small-scale industry capable of producing high-quality Italian olive oils, previously considered to be too expensive by consumers compared to imported oil.

The medium and small-scale industry, consisting of a large number of operators, has had a further increase due to the new EU Regulation laying down measures for the marketing of olive oil [5]: this law prohibits the trade of loose oil, and requires that, in the direct sale to the consumer, the oil must be packed in containers having a maximum capacity of 5 litres, and that the containers must hermetically sealed with throw-away caps and carry a label that corresponds perfectly to the content of the packaged product.

In order to keep up with their competitors, small producers will have to focus on differentiated products with high quality standards and a high added value: in the respect of the recent legislation and to continue the sale, they will therefore have to provide themselves with very flexible packaging systems, able to operate with different formats and materials. This represents a market opportunity for companies in the packaging industry and a typical case of market-pull.

Packaging is a very delicate aspect of the supply chain of olive oil [6,7]: in fact, it can directly effect the quality of the oil by protecting the product from oxygen and light, so to preserve its sensory quality and delay rancidity.

The materials used, time required for the filling and contact with oxygen or heat sources are the controlled parameters of a new system to be created.

Thanks to the use of methods that allow more systematic innovation overcoming the contradictions that arise from the analysis of the process, not only can we improve quality and reduce time to market, but can also develop a product with innovative solutions that on one hand respond to new market demands and specifications, and on the other improve existing solutions [8,9].

At the same time, the development of CAD/CAE analysis and virtual prototyping has profoundly changed the approach to the design: the possibility of analyzing and developing optimal technical solution, maintaining low levels of cost and time, has increased the level of reliability and the quality of the final products.

This document describes the process of development of a new product from identifying market opportunities: the aim of the authors was to create a simple and economic filling machine, that would enable the small user to fill containers of different formats and materials in a semi-automatic way, with a fair productivity and low operating costs.

2 The filling in the vegetable oil industry: state of the art

The offer of machinery capable of filling containers with liquids of low and medium viscosity is varied, but the filling systems specifically used in the oil sector are mainly of 3 fundamental types [10,11,12]: high vacuum filling, volumetric (or piston) filling and net weight filling.

High Vacuum filling is used for thick and viscous liquids, into containers which are resistant to vacuum, such as glass bottles. As opposed to the gravity or low vacuum system, the filling takes place by creating a vacuum inside the bottle through a separate channel (fig. 1), allowing the product to flow from the filling tank more easily.

At the end of the filling process, once the desired level has been reached, any excess product is collected into a dedicated reservoir and sent back to the main tank. The intensity of the vacuum is adjustable to suit the product density and the production speed.

This filling system ensures simplicity of construction, medium-high filling speed (depending on the vacuum created and the viscosity of the oil to be packaged) and accuracy in the filling level of the bottles. The disadvantages, however, are represented by the impossibility to fill containers of materials different than glass, for example PET or tinplate, since the vacuum would make them implode around the nozzle.

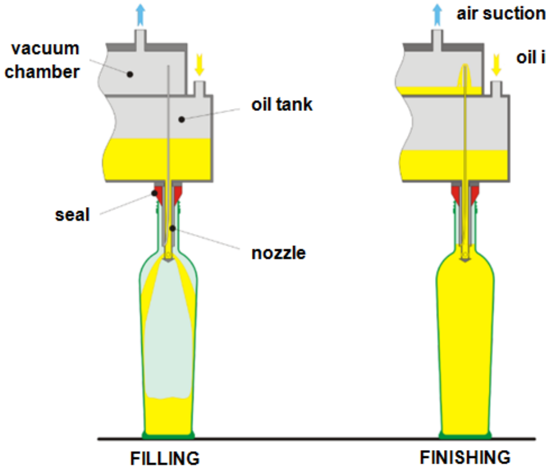

Fig. 1 High Vacuum filling.

Volumetric (or piston) filling system uses a cylinder which is filled (fig. 2) by means of the motion of the piston.

The filling system consists in two steps: during suction, the product passes from the tank to the metering chamber through a three-way valve which measures the product thanks to its piston-based operating principle, according to a preset quantity. To empty the chamber, the three-way valve activates a pneumatic valve controlling the piston: the product is pushed out of the cylinder into the container. The filling speed at the top portion of the container, where the neck must be filled slowly to prevent foaming or spillage, is adjustable.

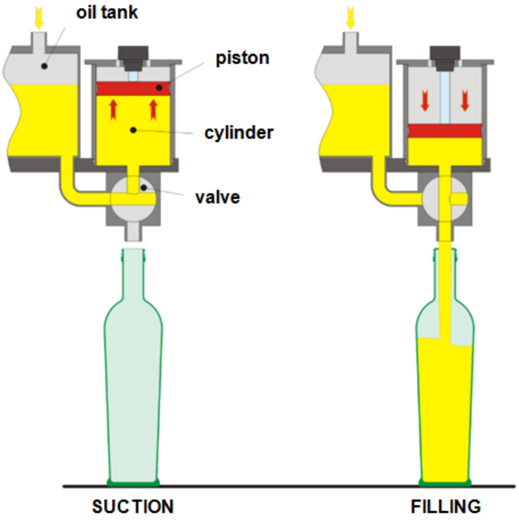

Fig. 2 Volumetric (or piston) filling system.

The advantages of this filling technology are definitely high filling speed, accuracy, in volume, of dosing and, above all, the fact that this system can be used to fill any type of container, either in glass or PET or tinplate. Important limitations of this system are the limited volume of the cylinder, intrinsic error of dosing and continuous adjustments required for different types of oil (specific weight) and for variations of the specific volume of the oil with environmental temperature changes.

The net weight filling system is absolutely the most accurate and versatile. It is based on the use of load cells and a retroaction control instrument (fig. 3).

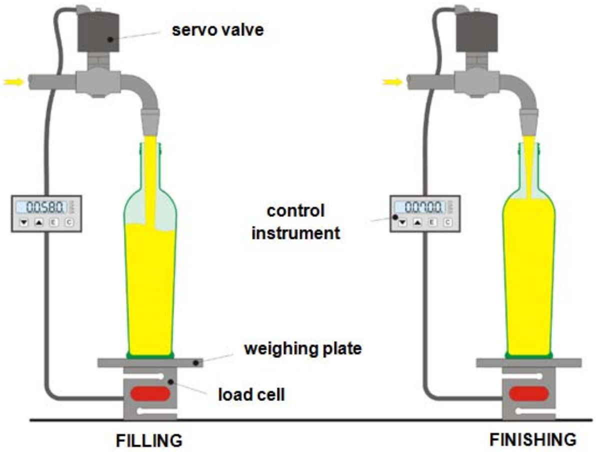

Fig. 3 Net weight filling system.

The filling system consists of a weighing plate with a loading cell, a servo valve and a control device capable of calculating the tare of the container and controlling the opening of the valve until the set net weight is reached. You can set two or more limit levels which correspond to different valve opening settings, so to increase the filling speed and accuracy of dosing.

This system is suitable for any type of container, with regards to both material and capacity. Furthermore, it allows to change the format of the container in an easy way, by simply resetting the filling levels on the control device, without having to make any mechanical adjustments.

Therefore, the correct selection of the filling method depends on the format and the material of the container. The containers used are of different material and capacity. In particular, materials used for bottling and packaging olive oil include plastic, glass, tinplate, aluminum, stainless steel, fiber glass and plastic-coated cardboard: the most common containers are tinplate, plastic and glass bottles, in various shapes and sizes.

The demand for new types of products, the growth of the market and the need to continuously differentiate (also in terms of packaging) show that a high level of flexibility represents a customer needs for packaging companies.

This need also comes out in interviews conducted on a sample of 10 companies.

The real advantage deriving from flexibility is, however, efficiency, that is, the possibility of having a complete and integrated – although economic - bottling line.

Currently the packaging line prevalent on the market is semi-automatic, followed by automatic and manual.

The first and the third ones have a low level of process specialization and a limited bottling capacity. On the contrary, the automatic machines present on the market ensure high production levels: usually the containers are transported and placed onto a filling carrousel by means of a feed belt and a screw conveyor, while the correct positioning of the containers under the filling dispensers is carried out by a transferring star-wheel. Therefore the presence of an operator is not required (Fig. 4). As well, transport of the container from the filler to the capper is performed by another transferring star-wheel. The use of different types of containers imply changing the transferring star-wheels, with complex and expensive mechanical operations, which make this system highly specialized and not suitable for the users described above.

On the other hand, the semi-automatic filling machines available on the market simply fill in different containers, while all transferring, positioning, capping and labelling operations are carried out by operators or by other non-integrated modules. These machines are therefore characterized by low productivity.

Fig. 4 Star-wheel system.

3 Design of the filling machine

For the design, we followed the traditional pattern of French [13], [14], identifying the needs of operators in the oil sector and analyzing the problems, in order to define the specifications of the machine. Then, thanks to the use of CAD/CAE tools, we evaluated the different solutions in terms of efficiency, in order to obtain the best possible result.

Furthermore, during the initial stage of conceptual design [15], the use of the deductive technique resulted to be fundamental: by using analogy with similar problems, we sought for solutions that were innovative or improving compared to the traditional ones.

3.1 Problem analysis and specification

So the first step is to define the specification of the product: a semi-automatic filling machine designed specifically for small oil-mills must be versatile, capable of filling very different products, in terms of volume, size and material of the containers, in compliance with the European standards of oil packaging, which impose the use of containers with a maximum capacity of 5 liters.

Generally, to differentiate production, oil producers have to buy several lines, each one with specific equipment for each format to be packaged. This involves a strong burden of business costs, first for the purchase of the machinery and numerous dedicated equipment, and then in terms of labour costs, due to the long time needed to clean and set up the machine. This leads us to deduce that the peculiar characteristics of a filling machine should be:

- Capability to fill a large range of formats.
- Filling volume ranging from 50 cl to 5 liters.
- Capability to fill containers of different materials.

- Simplicity of adjustment to adapt the machine to different productions, both in terms of the format of the containers and in terms of filling volume.
- Particular care of the product to be packaged.
- Compact size and weight so that the machine can easily be moved and reach the tank containing the desired product.
- Absence of tanks on the machine and maximum reduction of tubes and pass-throughs of the product. This, in order to avoid stagnation of the product and simplify the operations of washing and changing oil type.

3.2 Defining the concept

The idea is to produce a carrousel moved by a single drive group able to perform all required operations on any container type and format without having to change any component.

Therefore, for the general architecture of the machine it was decided to use the weight filling system, with a single load cell and weighing plate: this enables to meet the demand for versatile filling in a very simple way. It will be possible to fill in any format by simply setting the filling level values on the relevant retroaction instrument.

Instead, to adapt to the size of the containers without the need of additional equipment, the machine will be equipped with an easily adjustable gripper system and a manual lifting screw to adjust the height of the filling valve respect to the weighing plate. All adjustable moving parts needed to adapt to the container format will have millimetric rules and stoppers, so to reduce as much as possible the machine set-up time. Dedicated tables will indicate the parameters to follow for the correct positioning of these parts according to the format of the container.

With regards to filling, filling by gravity or by means of a screw pump is surely preferable to avoid submitting the oil to stress, thus avoiding the production of harmful emulsions [15].

The machine will have a base with a simple and regular shape, and small dimensions: four wheels will allow to approach the machine to the storage tank containing the oil to be packaged.

Lastly, the machine has no need of compressors, water or other annoying connections [16].

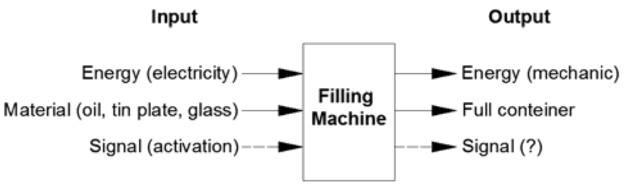

Fig. 5 Global black box.

We can schematically outline the operation of the machine through a global black box (fig.5), and divide it in following sub-operations:

- Introduction of the empty container;
- Filling;
- Capping (optional);
- Unload of the full container.

In conclusion, the machine, not inserted in a rigid line of production, will have a semi-automatic operation, i.e. the operator will carry out the phases of introduction of the empty containers and unload of the full ones. The machine is designed to perform in automatic the filling and capping (optional) operations, and also the transport of the containers during these intermediate phases. This implies that the machine operation will be intermittent during the phase of transport of the containers, so as to have automatic transport between the various phases, but will also a dead time to allow the operator to perform the introduction and unload phases. Moreover, in order to reduce the dead time and allow a single operator to perform these two phases simultaneously, the machine is of the rotary type, that is a kind of closed loop. The operator will never have to move from his work station, from which we will operate so that the machine will work without interruption.

3.3 CAD modelling and analysis

When every filling machine you build is one of a kind, you need to design it right before it goes into production. CAD software provides a wide range of virtual prototyping tools that can help you to correctly identify and solve problems up front. Once having defined the specifications [17], we carried out the phase of CAD modelling and analysis to develop the various components from the idea of whole, following a top-down approach. In this stage, for the type of application involved, tool is particularly useful allowing to analyze and simulate the kinematics of movements in a simple and precise way.

The machine we designed (Fig. 6) has a square base in AISI 304 stainless steel, like all the parts in contact with the oil. The workplace is unique, and is placed in front of the control panel, where there is a support tray for the containers.

The necessary connections to the machine (electricity and oil pipe) are on the right hand side, where an accessory socket for the use of an external pump is also found.

The central axis consists of a mobile part, used for the transport of containers, and a fixed part used as a housing for the control panel and a support for the metering valve. The mobile part is divided into six parts (stations). During operation, which is intermittent, each 60° rotation of the stations correspond to a stop at a position of the fixed part. Basically, there are six stops (stations) during which an operation on the container is performed. The machine is designed so that the filling system can eventually be doubled and a capping system can be attached to its base. The six stations correspond, in sequence, to the following operations:

- Introduction of the empty container;
- First filling;
- Second filling (optional);
- Cap capture;
- Capping;
- Unload of the packaged container.

The components needed for machine operation are numerous, innovative and in some cases complex.

An innovative element of the machine is definitely the introduction and container movement system.

The containers are transferred among the six stations of the machine by a hook in high density PE. The innovation of the system consists in the movement of the hook that, at each stop of the machine, at stations 1, 2 and 6, is lifted and releases the container. At stations 1 and 6 this facilitates the task of the operator, who is thus able to load and unload the machine simultaneously by just slipping the containers onto the tray without having to pick up the full ones, which can achieve significant weight (approximately 4.9 kg for containers of 5 liters). At station number 2, dedicated to filling, the rotation of the hook that releasing the container has a different function: the container that occupies this station is positioned on the weighing plate and therefore the contact with the hook would create friction that would distort the reading of the load cell.

Fig. 6 Semiautomatic weight filling machine.

Once the operator has performed the simple set-up that consists in adjusting the seats where the containers will be positioned and setting the net weight of the oil to be filled, the machine is ready for packaging. At each step of the machine, the operator loads the empty containers and unloads the full ones.

At the beginning of each cycle of stop, an optical sensor mounted on station 2 detects the presence of a container to be filled on the weighing plate. If a container is detected, it weighs the tare weight and a second later it begins the filling operation. The metering valve fully opens and the oil begins to flow into the container. This condition remains unchanged until the weight reaches the value of the first set level. At this point the oil flow is reduced, the finish filling begins and continues until the set net weight is reached.

During the filling phase, power is also supplied to the socket for the use of an external pump. A screw pump on a trolley would commonly be used. The use of a pump is required in case the sash from the storage tanks is limited, or if the oil is stored in tanks located under the floor level.

The subgroups constituting the filler are the following:

- Base;
- Drive group;
- Torque limiter;
- Central axis;
- Lifting;
- Introduction;
- Valve and weighing device.

The base subgroup contains the entire structure of the filler: the *drive group, central axis, lifting, valve and weighing* groups are fitted to the base by means of threaded connections. The frame is made of tubular steel and metal sheet in AISI 304; it contains a tray to collect the oil that could spill during processing, as well as the electrical control panel with the main switch. The base is mounted on four wheels that allow easy transport.

The drive subgroup includes all the mechanisms adopted for the motion of the filler. As the machine operation consists of several coordinated and repetitive movements, the machine must always be in phase.

Of course, the best way to achieve this result is to ensure that all movements are generated from the same shaft, therefore by a single motor.

To achieve the intermittent movement of the machine, we have chosen to draw a dedicated mechanism; this choice was both economic and technical.

This mechanism is constituted by a cylindrical cam and a disc mounted on skew axes (fig. 7). An open trajectory is engraved on the cam (milled), while the disk houses idle hardened studs, one per each station of the machine, placed at 2π/6 from each other: when the machine is in dwell phase, the cam is interposed between two contiguous pins.

The length of the profile of the cylindrical cam is at this stage equal to the internal cord (l) between the two studs. In this way, even if the motor shaft rotates, the central axis of the machine is motionless. Continuing in the rotation, a stud engages the inner part of the trajectory groove milled on the outer cylinder of the cam, crossing it from side to side. In this way, as a result of a rotation of 2π of the motor shaft, there is a rotation of 2π/6 of the central axis (phase of motion).

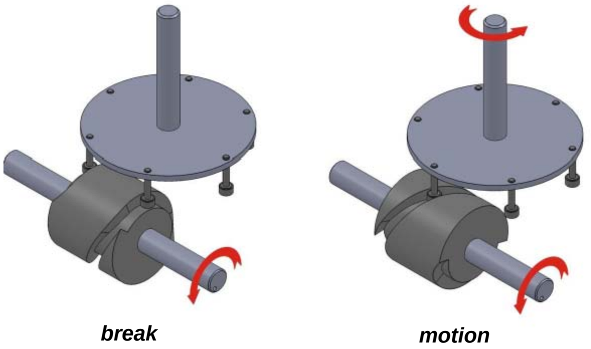

Fig. 7 Mechanic rotation by cam.

Of course, the movement of the central axis (which is conducted) responds to a law determined by the profile of the trajectory engraved in the cylindrical cam and can easily be customized and adapted to the needs of the work cycle.

In particular, one can vary the dwell and movement times with the angle α and the accelerations and decelerations with the angle β, by varying the inclination of the ramp of the trajectory; also, by changing the value of the radius of curvature R, it is possible to obtain movements having the desired fluidity (fig. 8).

In the case under study, we have chosen a profile specular with respect to the centerline of the cam, with a reduced slope of the ramp of the trajectory with a 25° angle and large adjoining radii in order to obtain a smooth movement of the container that must be pushed and slipped without bumps and jolts. The angle α, which is dedicated to the movement, is approximately 260°. The further rotation of the motor shaft up to a round angle, at which the central axis will be immobile, will serve to operate the mechanism which releases the containers (*introduction* subgroup).

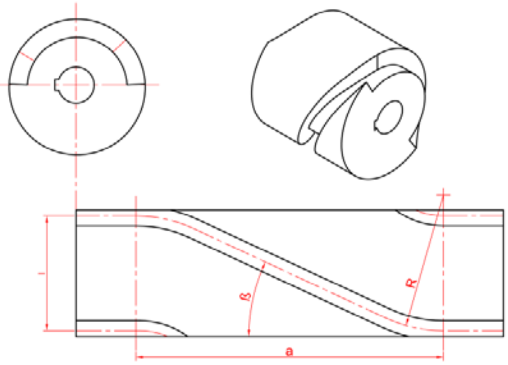

Fig. 8 Cam profile.

To obtain the movements we have used a 900 rpm motor, coupled to a worm reduction gearbox having a reduction ratio equal to 60:1: in this way the movement from one station to the next one will take approximately 3 seconds. The reduction gearbox used allows to mount two pinions that, on one hand, transmit motion to the mechanism that locks the containers and, on the other, allow to add additional drives which act in a synchronous way with the rest of the machine (fig. 9).

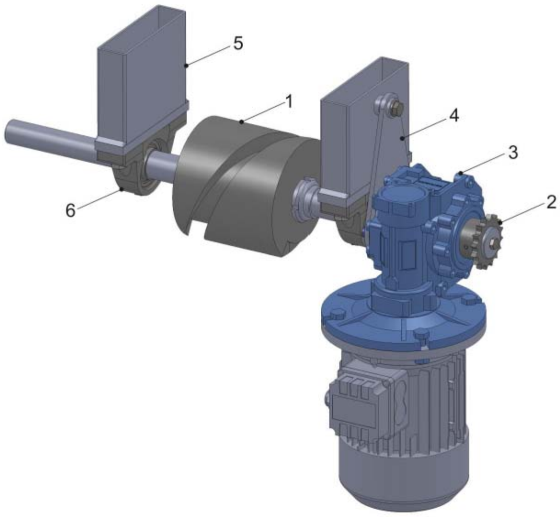

Fig. 9 Reduction gear.

A further feature of the machine is the torque-limiting device mounted on the rotating part of the central axis: its functions are to avoid that the machine crushed or grinds any container placed in an incorrect position, and, above all, to ensure the safety of the operator coming in direct contact with the moving parts of the filler. The device that has been designed is a safety coupling, able to produce a real decoupling between the drive shaft and the moving part in the event of overload, and allows to restart the motion from fixed positions, so as to respect the synchronism among the organs in movement.

The whole subgroup is fixed to the central axis. There is a lower hub (fig.10-1) fixed to shaft by means of a tongue; instead, the upper calotte (fig.10-2), where a bushing in self-lubricating material is inserted, can rotate idly on it. Six idle stubs are position around the cam at distance of 2π/6 from each other. The studs (fig. 10-3) are in commercial use, have a hardened outer thrustbearing and rollers for sliding and can easily be greased. The motion is transmitted to the calotte by means of the studs from the rotation of the cylindrical cam described above.

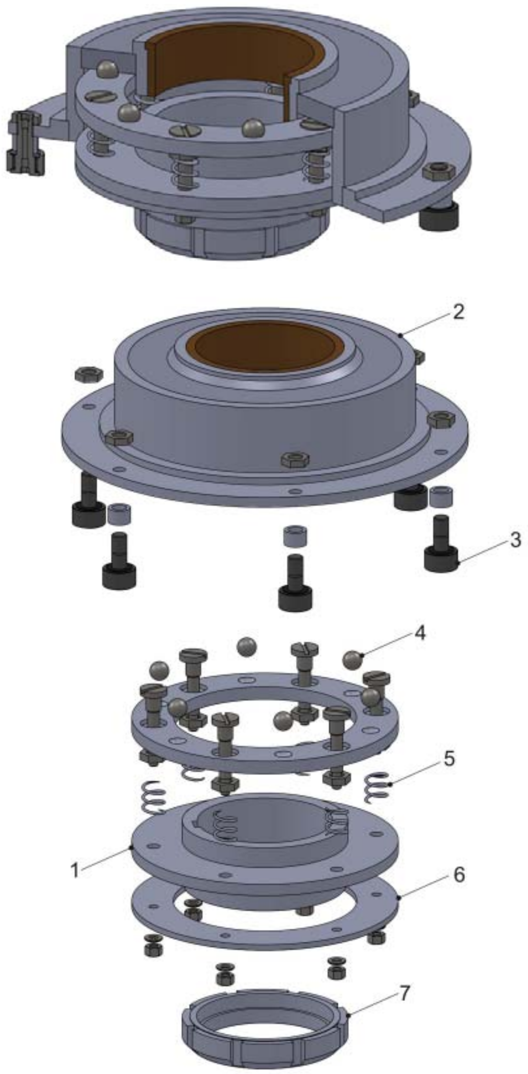

Fig. 10 Torque limiter.

When working in normal operating conditions (fig. 11-(a)), the calotte transmits torque through a flange with six spheres (fig. 10-4), forced by the pressure of the springs (fig. 10-5) inserted into hemispherical seats machined in the calotte and the underneath flange.

The seats engraved in the flange have a depth greater than the radius of the sphere, so that the spheres cannot come out until the entire group is assembled.

When the torque transmitted exceeds the preset value (fig11-(b)), the spring force is overcome and, as the springs shorten, they release the driving and moving parts, and activate an electrical emergency switch that stops the machine completely.

The filler can be reset and will restart only once the coupling has returned to its normal position, that is, the spheres are in their housing and the emergency switch is released. As there is one hemispherical seat engraved in the calotte for each station, this implies that the machine will necessarily restart in phase.

Another important aspect of this coupling is that the limit torque is adjustable.

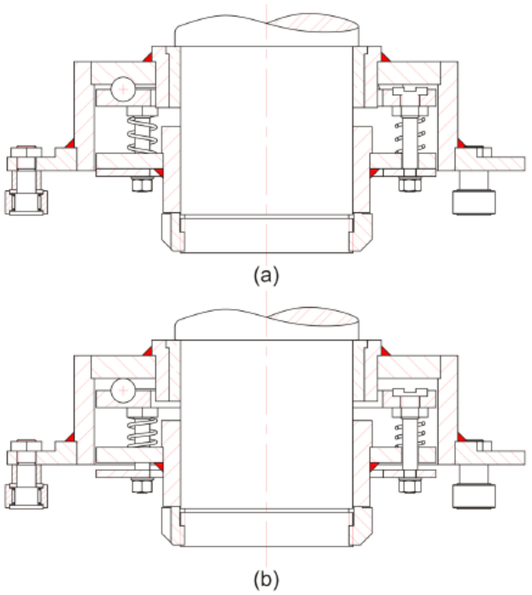

Fig. 11 Operating conditions - (a): Normal - (b): Overload.

The central axis subgroup (fig. 12) consists of three coaxial elements, of which the outer and the inner ones are fixed, whereas the intermediate one is pivoting: the rotation of the axis, connected by means of a tongue to the torque limiter, moves the driving disk which is fundamental part of the machine (fig. 12-5). The hollow-shaped fixed part (fig.12-7) allows the passage of the electrical cables and the oil tube. The control board and control switches are housed on its upper end.

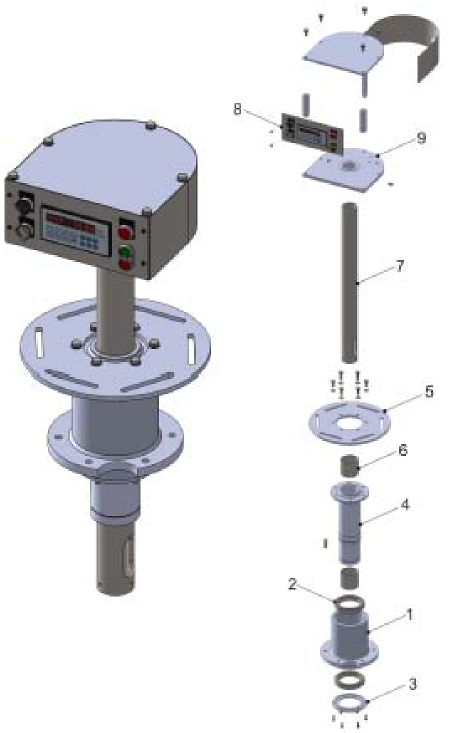

Fig. 12 Central axis subgroup.

The system is able to vary its height according to the type of container (net stroke 150 mm), by means of a coupled screw and lead-screw with trapezoidal threading TPN 50x8 (fig.13, lifting subgroup).

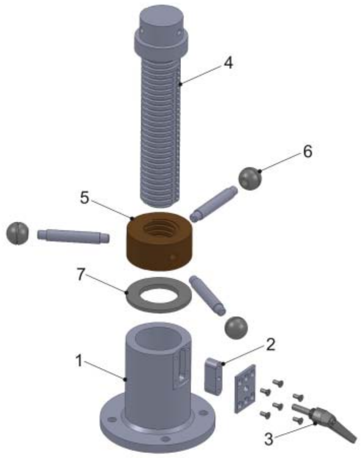

Fig. 13 Lifting subgroup.

The introduction subgroup is the most innovative part of the designed filler. It allows to use the machine with any format, without the need for auxiliary equipment.

By means of the hooks, the machine drags the containers on a tray in sheet metal, dragging them from one station to another.

This mechanism uses the intermittent motion of the machine and is driven directly by the motor shaft (fig. 14): a rotation of 360° of the motor shaft corresponds to a 260° rotation of the central axis of the machine. This means that within a range of a 100° rotation of the motor shaft, the machine will appear to stop, i.e.: it will be in dwell phase. The hooks open exactly during this phase of free rotation obtained by a cam mounted onto the motor shaft: when rotating, the cam raises a crescent-shaped plate which actions the lever mechanism designed for the rotation of the hook.

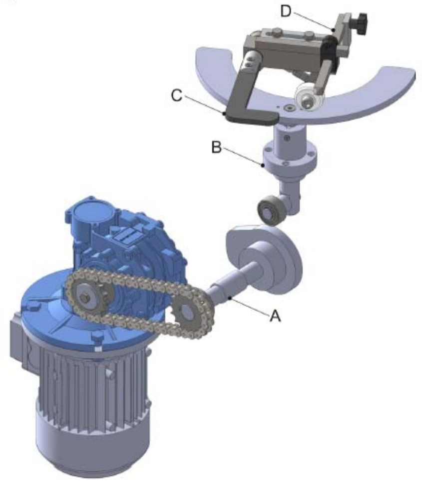

Fig. 14 Introduction subgroup.

The circular cam has a single, not desmodronic, profile and therefore, to make sure that the bearing is always in contact with the cam, a reaction spring pushing the stud downwards is inserted it the support (fig.15-6).

The plate fixed onto the shaft pin (fig. 15-7) and working as a cam for the six mechanisms of the moving hook, is a segment of an annular plate. Its particular shape is due to the fact that, when it is raised, the plate must action the lever devices of three contiguous stations. The lever devices are positioned at 60° from each other and are moveable so to adapt to formats of different sizes;

therefore the arc that interferes with the cam is greater than 120°.

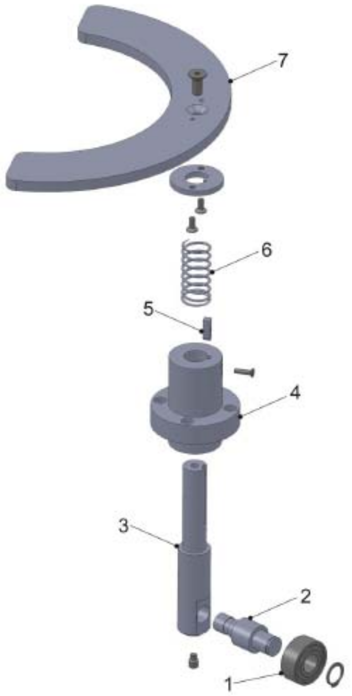

Fig. 15 Introduction subgroup - exploded view.

The transport system is made up of a hook (fig.16) that drags the containers among the stations of the filler, and a guide system (fig.14-D), consisting in an adjustable support and two square profiles, a front one and a side one. The side guide performs two basic functions: it allows the positioning of the container in the correct place and avoids any shaking of the containers while they are being dragged.

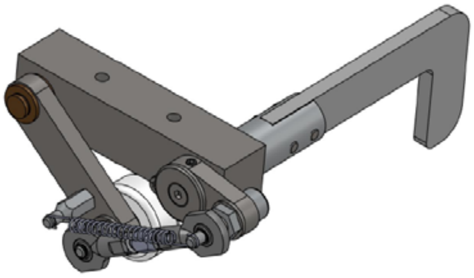

Fig. 16 Hook mechanism.

In fact, during the loading phase the hook is lowered (fig. 17-b) and can bring the empty container to position. Once in contact with both front and side profiles, the container is surrounded by the transport system and perfectly centered during the filling phase and in the eventual capping phase.

The rotation of the strinking roller, on which the hook is mounted, is obtained by a system consisting of two levers connected by an arm with two spherical joint terminals. The arm, which has an adjustable length, not only transmits the motion, but has also the function to vary (during assembly) the rotation degree of the hooks.

The mechanism transforms the lifting by 25 mm of the wheel into an exact 90° rotation of the hook.

A return spring additionally connects the two levers of the mechanism, and has the function of bringing the hook back to closed position once the cam is no more activated.

The lever devices for the rotation the hooks and frontal guide are connected to each other, with the drive disc of the central axis subgroup interposed between them.

On the disk there is a long slot, where the locking pins are fitted through a centering bushing. In this way, by loosening only two pins, it is possible to adjust both the center guide and hook devices.

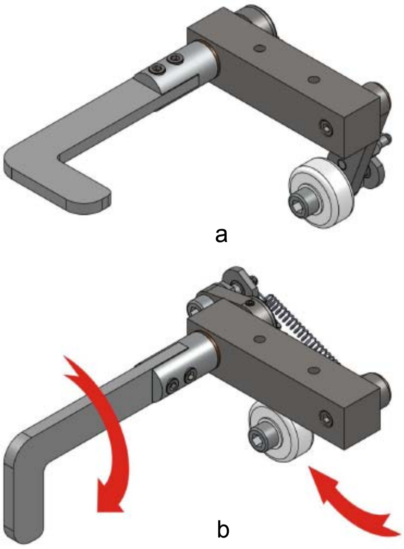

Fig. 17 Hook: working positions.

From the operation described above one can deduce that the hook is one of the most solicited components of the machine; therefore a Finite Element (FE) analysis was performed using Solid Works software [18], under static load conditions to evaluate the critical condition of the model [19].

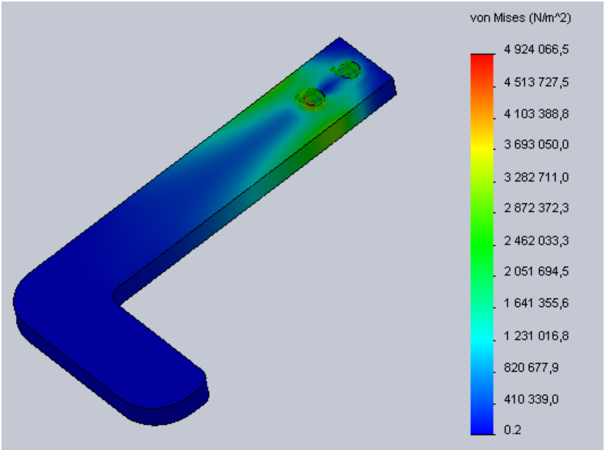

Fig. 18 Stress analysis.

Fig. 18 shows Von Mises equivalent stress distribution made assigning the material proprieties corresponding to a high molecular density polyethylene and a load of 75 N.

Once the containers have been transported into position, filling is carried out by the control and weighing system. In particular, the weight dosing is controlled, through the reading of the weight of the container, by an electronic device that performs the functions of display and control.

The device has different packaging sizes programmed in its memory, and for each of them there are two set values or limit values. The filler fills up quickly until the weight reaches the first set value, after which the filling takes place in the finishing mode, with a limited flow. This feature is important for obtaining precision in the dosage and prevent splashes and spills of product from the containers.

This is achieved through the use of two solenoid valves mounted in series on the pipeline. The first one is a choking valve (fig. 19-1) that reduces the flow by approximately 70%, whereas the other one is a metering valve (fig.19-2) that completely blocks the flow once the predetermined net weight is reached.

The central pipe (fig.19-3) is all integrated inside the machine, fixed to the bottom plate of the instrumentation by means of a tube-locker in plastic material. Two flexible parts (fig.19-4) in Armovin coiled tubing are mounted at the ends of the central pipe and allow on one end to adjust the height of the central axis, and on the other to center the dispensing valve on the neck of the container.

All joints can be made with tri-clamp or Garolla type fittings.

The metering valve is also fixed to the bottom plate of the instrumentation. Specifically, it is mounted on a plate with a slot which engages a rotary support (fig.19-5). This system allows great freedom of movement and also allows quick centering and clamping by simply tightening a three-spoke adjusting knob.

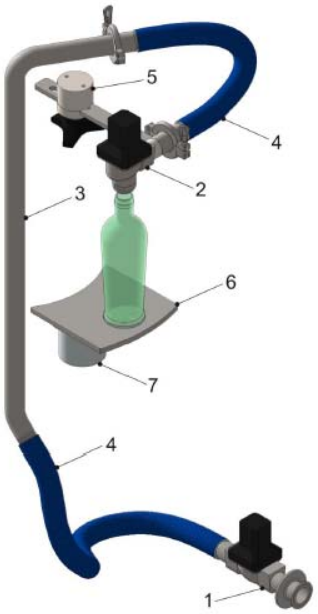

Fig. 19 Filling and weighing system.

Weighing is performed by an off-center type load cell, which allows consistent weight readings wherever the container is positioned on the weighing plate.

A steel weighing plate (fig. 19-6), perfectly integrated with the container guide tray to avoid any shaking of the containers while they are being dragged, is fixed to the upper side of the cell.

On the lower side, the cell is attached to the support of the cell itself (fig.19-7), and locked to the upper plate of the frame, where a hole has been obtained to allow the passage of the cell reading transmission cable.

4 Conclusion

A careful analysis of the olive oil market has shown the need for a filling machine that responds to the needs of the mills, which have become new packers in the light of the new regulatory framework for the marketing of extra virgin olive oil.

We have evaluated the current offer of the filling machine industry and the needs of the customers and have defined a new concept of product. Once we have defined the general architecture, with the use of a CAD/CAE software we have designed in detail new filler with numerous features that make it unique in the market: the machine is semi-automatic, rotary, closed loop and all movements are obtained by a single drive group.

Thanks to the adoption of the weight filling system, the machine is able to fill containers of different shape, volume and material. The original and simple set-up system set-up allows to switch from one format to another through simple mechanical adjustments of the introduction organs, without the need for expensive additional equipment.

The rapidity of the set-up of the machine, the absence of stagnation points of the product, combined with the small dimensions and weight, make it mobile and suitable to fill even small quantities of different products.

The use of the CAD/CAE techniques allowed to develop and to analyze different solutions in a very short time, without the need to build any physical prototype before defining the final one.

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