SIPREM INTERNATIONAL Srl – Via Lazio, 8 – 61100 PESARO ITALY

COOLING CRUSHED GRAPES USING LIQUID CARBON DIOXIDE

4. PLANT WITH DIRECT IN-LINE INJECTION (Capacities from 10 or 30 TON/HOUR and delta t = -10°C)

The plant comprises:

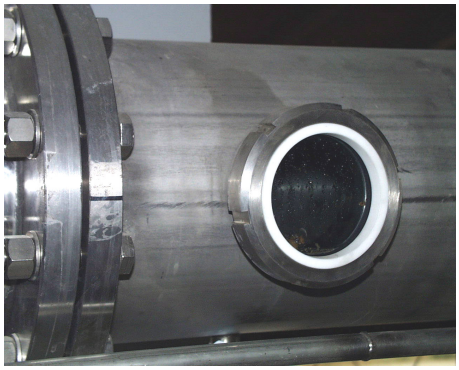
- Liquid carbon dioxide injector
- Transfer pipeline
- Solid-gas separation cyclone complete with condensation separator
- Unit for regulating and controlling process data (level, pressure, temperature), electrical control console.

4.1) CARBON DIOXIDE INJECTOR

The carbon dioxide injector consists of a system of pneumatic valves which are electrically controlled, each with a given flow of liquid carbon dioxide calibrated by means of special nozzles which intercept the cooling liquid; they are activated in sequence according to the amount of refrigeration required.
The injector inlet consists of a pipe into which an initial carbon dioxide injection nozzle is fitted, used to move the grapes inside the pipeline in the right direction and which is activated each time the pumping system is put into operation.
This nozzle is calibrated in such a way as to feed in the minimum amount of refrigeration required.

The diameter of the grape pipe is then increased by means of a suitable adapter, and the rest of the nozzles are activated to feed in the carbon dioxide needed for the process; the number of nozzles is calculated according to the maximum refrigeration required from the plant. The pipe coming out of the injector is of such a diameter as to obtain a maximum treated product transfer speed no greater than 10 m/s, in order to keep possible breakage of the individual grapes down to the absolute minimum.
In the injector outlet area there is a temperature sensor with the task of signalling any malfunctions in the injection system, while in the inlet area there are a pressure switch and a safety valve able to detect any blockages of dry ice.

4.2) TRANSFER PIPELINE

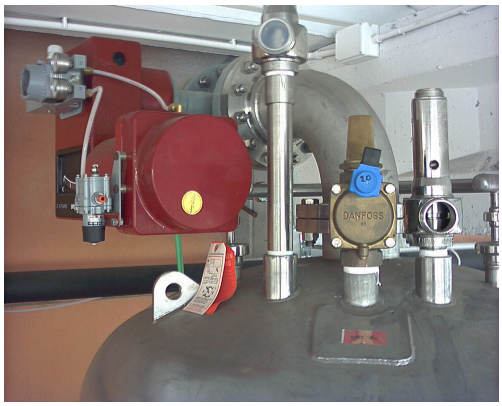


This serves the purpose of connecting the area where the injector is located to the separation cyclone and of prolonging the contact time between the product and the cold carbon dioxide gas.
Like the previously described injector, the transfer pipeline has a large diameter and the internal surfaces are designed is such a way that the product will not be damaged. This pipeline is of sufficient length so that, along its journey, the product can lose calories and exploit fully the refrigerating action of the carbon dioxide gas.

The pipeline is fitted with temperature sensors which send to the electrical control console the refrigeration values needed for the process and control the temperature of the treated product. Where necessary, small windows can be fitted to the pipeline so that the product flow can be monitored visually.

4.3) SOLID – GAS SEPARATION CYCLONE

The cyclone is a vertical tank with an inlet to receive the product from the injection area and a bottom vertical outlet for the treated product; by exploiting the principle of cyclones and centrifugal force of the solid/liquid cooled product different from that of the gas, the crushed product is therefore separated inside from the gasses which are made to escape from the top as the crushed product deposits itself at the bottom.
To allow the crushed product to escape, or to send it to a height above that of the cyclone position, the internal pressure of the cyclone is controlled, managed by a level indicator and a modulating valve for regulating the gas being dispersed.
The system is managed by setting on a control PLC level to be maintained inside the cyclone; if the level increases, the gas regulator valve modulates to the closed position to create an increase in pressure inside the cyclone and a consequent lowering of the level. Vice versa, if the level drops the gas regulator valve modulates to the open position causing a decrease in pressure inside the cyclone and a consequent raising of the level.
The cyclone is equipped with a washing system using water through the washing ball valves provided in the top part. On request a manhole can be fitted, so that the inside of the cyclone can be inspected.
In the top inner part of the cyclone there is a second solid/gas separator to recover the last residue of crushed product and the condensation not previously separated.
On the outlet of the separator there are the gas regulator modulating valve and the safety valves for discharging any excess gas pressures which may form in the event of system malfunction.

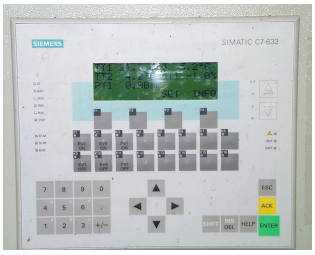


4.4) UNIT FOR REGULATING AND CONTROLLING PROCESS DATA

The system is equipped with a fully automated unit for regulating and controlling the process parameters, comprising:

- Safety valves;
- Safety pneumatic ball valves;
- Solenoid valves and pneumatic system for valve control;
- Electrically controlled pneumatic valves to shut off liquid $C0_{2;}$
- Safety valves to signal any excess pressures;
- Temperature sensors;
- Gauges;
- A level indicator to show constantly the actual level of crushed product inside the separator;
- Safety indicators to signal maximum level inside the separator;
- Continuous transmission of the pressure inside the cyclone;
- Modulating butterfly valves to regulate the pressure inside the cyclone and consequently the level of crushed product;

The cycle as a whole is managed by a PLC that controls the working processes throughout the plant using the contacts and electrical signals coming from the equipment installed on-site.
The electrical control panel is also used to manage all the alarms, so that total safety can be ensured for both the production and the operating staff.



5. ESTIMATED CONSUMPTION OF LIQUID CO_2 ACCORDING TO THE DELTA TEMPERATURE REQUIRED

The liquid CO_2 is stored in tanks at 20 atm. and at a temperature of –20°C; by expanding up to 1 atm. it cools to
–78 °C and transforms 48% into dry ice (solid) and approx. 52% into gas (vapour).
By sublimation the dry ice takes away heat from the product to be cooled. More heat is taken away by the CO_2 gas being heated up from –78°C to the discharge temperature into the atmosphere.

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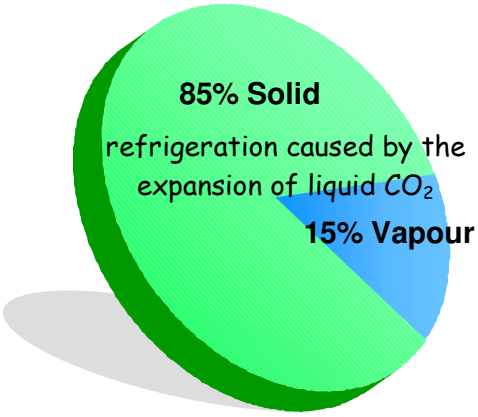

1 Kg of liquid CO_2 takes away 80 Kcal (334.7 kjoule) with a final gas temperature of –20°C

The table below gives the estimated consumption of liquid CO_2 according to the delta t required on the product (crushed grapes). Consumption is estimated on the basis of a product Sh (specific heat) of 0.65 kcal/kg/°C:

IN-LINE INJECTION :

Temperature Delta	**Consumption of liquid CO_2 per quintal of crushed grapes**
10°C (example: from 25°C to 15°C)	10 Kg
15°C (example: from 25°C to 10°C)	12 Kg
20°C (example: from 35°C to 15°C)	15 Kg
30°C (example: from 40°C to 10°C)	21 Kg

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