POLITECNICO DI TORINO

Corso di Laurea Magistrale in
Automotive Engineering

Tesi di Laurea Magistrale

Standardizzazione e trasversalizzazione dei metodi di gestione della qualità su di un processo di massa production

Relatori:

Prof.Paolo Chiabert

Ing.Daniele Canavesio

Candidato: Ahmad Diab

Politecnico di Torino & Denso Thermal Systems

Ahmad Diab

There is no mass production without standardization, there are no high output machines without mass production. “Therefore standardization is causal in competitiveness"

ISUG

ACKNOWLEDGMENTS

First, I would like to thank DENSO THERMAL SYSTEMS for this opportunity to perform this work, it has been a great learning experience.

I offer my enduring gratitude to Daniele Canavesio.His exceptional knowledge, wisdom and understanding have inspired and motivated me.

Prof. Paolo Chiabert, thank you for all your assistance before and during this task, and for keeping me on track.

Besides my supervisors, I would like to thank the quality team, I’m grateful for your support.

I would like to thank everyone that helped in this work, apologies for not naming each member, but you know that I am grateful for all your support throughout.

I would like to sincerely thank my parents for providing me with unfailing support and continuous encouragement throughout my years of study. I will be grateful forever for your love.

DENSO
Crafting the Core

ABSTRACT

In order for companies to survive and stay competitive in today's market, it is very important to ensure consistency in their operations because it increases efficiency. However, because of different ways of executing the same process by different workers, due to different skill levels, education or experiences, it is hard to maintain the required consistency and that might result in variations in the produced products or services. The aim of this project is to study the creation of standardized work according to Lean, as well the training process of unskilled personnel to perform production tasks in an efficient way. This thesis will concentrate on creation of work instructions making standards of different kinds of condensers in order to have efficient work and mainly to decrease the percentage of internal and external scarps which costs the company huge amount of money every year,

The idea is to implement this work instructions to all the phases related to the production of the condensers starting from the first phase, procedure of making the tubes needed for the condenser, till the last phase which is packaging in order to have the products ready for the shipment.

The work instructions must be part of closed cycle which consists of control plan, Fmea, Process flow to have complete information needed for the worker to make efficient work and also for the supplier to make them comfort about the products they are buying.

The work instructions done were approved from the head of the quality department, the health and safety executive responsible and from production area manager

Moreover the work instructions were discussed by the suppliers (GENERAL MOTORS, IVECCO, RENAULT, PSA, and MASERATI) where I had the opportunity to participate in the meetings when considering the audit visits to take some notes and improve the work instructions

Our project is not just to reduce the percentage of scraps in the internal company but also to have the satisfaction of the customers which is one of the main goals of the quality.

CONTENTS

CHAPTER 1 INTRODUCTION 10
1.1 Background 10
1.2 Problem statement 11
1.3 Objectives 11
1.4 Thesis Outline 11
CHAPTER 2 DENSO THERMAL SYSTEMS 12
2.1 Denso Corporation 12
2.2 Denso Thermal Systems 15
2.3 Location 16
2.4 Denso-TS Market 17
2.5 Plant of Poirino 18
2.6 Quality in Denso Thermal Systems 19
CHAPTER 3 The Thermal system 24
3.1 The interior system 24
3.2 General information on cooling systems 26
3.3 The condenser what it is and how it works 27
3.4 Distributor components 37
CHAPTER 4 CONDENSERS 40
4.1 Pull production 40
4.2 Phases of production process 40
4.2.1 Distributors of production process 41
4.2.2 Assembly process 48
4.2.3 Brazing process 51
4.3 Sequence of the process 53
4.4 Final assembly amd testing 58
4.5 The repair of condenser 61
CHAPTER 5WORK INSTRUCTIONS 67
5.1 Introduction 67
5.2 Structure 68
5.3 Results 73
5.3. 1Data collection system 73
CHAPTER 6 79
6.1 Conclusion 79
6.2 Future Work 79
References 82

LIST OF FIGURES

Figure1: Standards improve productivity 10
Figure 2 :Engine control systems 12
Figure 3: Starter motor 13
Figure 4: Panel board 14
Figure 5: Windshield washing system 14
Figure 6: Denso in the world 17
Figure 7: Percentage of sales per customers 17
Figure 8: Customers of Denso Thermal Systems 18
Figure 9: Functions of the interior heating system 21
Figure 10: Scheme of a cabin thermal system 22
Figure 11: Refrigerator cycle 23
Figure 12: Scheme of an air conditioning system 24
Figure 13: Frontal section 25
Figure 14: Operation of an air conditioning system 26
Figure 15: Brazed condenser 28
Figure 16: Componens of condenser 29
Figure 17: Fins section 30
Figure 18: Shutters 30
Figure 19:Internal section of multiport tube 31
Figure 20:Multiport tube 31
Figure 21:Distributor on the filter body side 32
Figure 22:Block side distributor 32
Figure 23:Distributor cap 33
Figure 24:Sealed / unsealed filter body 34
Figure 25:Fianchetto 35
Figure 26:Side joint - Distributor cap 35
Figure 27:Filters 36
Figure 28: Pull Production 38
Figure 29: Distributore lato corpo – filtro 39
Figure 30: Distributorelatoblocchetti 39
Figure 31:Flow chart 42
Figure 32: Notch Point 43
Figure 33:Fori 44
Figure 34: Seat-septum and septum 44
Figure 35: Tenon cap 45
Figure 36: Distributor example 45
Figure 37: Block out and in 46
Figure 38: Fin formation process scheme 48
Figure 39: Fin centering / pipe alignment 49
Figure 40: Brazing with nocolok flux 50
Figure 41:Brazing process sequence 51
Figure 42: Hot air circulation 52
Figure 43:Flushing 53

Figure 44:Fluxed condenser 53
Figure 45:Hot air circulation 54
Figure 46:Particular steel "muffle" oven 54
Figure 47O-ring 57
Figure 48: Seger 57
Figure 49: Repair bench 60
Figure 50: Example of short fins 60
Figure 51: Pipe poorly planted 61
Figure 52: Damaged side 62
Figure 53: Side not brazed on the side 62
Figure 54: Defects on the block 63
Figure 55: Defects by welding 64
Figure 56: Approval and safety 66
Figure 57: Layout 67
Figure 58: Phases of work 68
Figure 59Scheda RilievoDati 68
Figure 60: Measurments instruments 69
Figure 61: Examples of defects 70
Figure 62: Fogliospunti 70
Figure 63: Kind of failures 72
Figure 64:Assembly defects table 73
Figure 65:Cost distribution 74
Figure 66:Percentage of scraps per model 75
Figure 67:Distribution of scraps per model 75
Figure 68:cost of scraps 76
Figure 69:Distribution of scraps 76
Figure 70: Percentage of compliant from first time 77
Figure 71: Percentage of scraps before rework 78
Figure 72: Percentage of scraps after rework 78

LIST OF SYMBOLS

ISO: International Organization of Standardization

ISUG: Impacts of standards users group

CHAPTER 1

INTRODUCTION

1.1BACKGROUND

Companies all over the world are trying continuously to enhance their service level and lower their costs, due to the high competition level in the global market. There are many strategies and tools that can be implemented by organizations to accomplish these goals. One of the methods that was implemented by many organizations in different fields is standardization approach.
It is essential in assembly line to have standardized tasks in the production process. Because maintaining regular output and timing and predictability by standardization is the basis for creating continuous flow and reduction of the internal percentage of scarps. As well standardization ensures continuous improvement process and work force growth and empowerment by continuously incorporating the employees' creative improvements into the system.

Figure1: Standards improve productivity

1.2 PROBLEM STATEMENT

In order for companies to survive and stay competitive in today's market, it is very important to ensure consistency in their operations because it increases efficiency. However, because of different ways of executing the same process by different workers, due to different skill levels, education or experiences, it is hard to maintain the required consistency and that might result in variations in the produced products or services. If the best way of performing documented work instructions as a standard to be followed by all workers, it will help in getting less variations and guarantee higher quality in the output. Therefore, many organizations are interested in standardizing their processes.

1.3 OBJECTIVES

We have several objectives for the project, but all with the same purpose: reduce the percentage of scarps concerning the production of the condensers.

This was possible through:

Creation of work instructions for the production of the work instructions including all the phases which the workers must take as a reference, in addition to training process of the workers to perform production tasks in an efficient way.

It is vitally important to eliminate waste to be more competitive in terms of prices on the market and secondly to offer customers a high quality standard. The decision to focus my attention precisely on the condenser was strategic: it is the most complex product to produce and at the same time the one with the highest added value.

1.4 THESIS OUTLINE

We will start first to take an overview about the DENSO THERMAL SYSTEMS and mainly on the quality department. Secondly we will describe the procedure for the production the condensers, then the concentration will be on the creation of the work instructions by describing all the steps in order to have complete and efficient work instruction and how these instructions are implemented in the assembly line. Using the data collection system used in denso thermal system we can have the results of the percentage of scarps in order to make our conclusion on how the work instructions implemented and the training of the workers had a positive effect on them.

CHAPTER 2

DENSO THERMAL SYSTEMS

2.1 DENSO CORPORATION

DENSO is a company with an almost global presence, characterized by a very high orientation towards innovation. It is also continually expanding towards sectors which are of strategic interest or which are characterized by a certain level of "fermentation".

The philosophy of DENSO is extremely important, because this particular company wishes to anticipate the times, achieving, moreover, a very high customer satisfaction. Not only is it important to be a global supplier, but you also need to be the best partner for your customers.

It currently operates on five continents, in practically every business area. The head office is in Japan.

The sectors of activity of DENSO

The business sectors of DENSO can mainly be divided into two, which in turn can be further divided:

AUTOMOTIVE:

Engine control systems: consist of systems and components aimed at ensuring engine control

Figure 2 :Engine control systems

Electrical systems: DENSO produces power supplies electrical components for the motor and safety systems. Among these, the most popular products are starters, alternators and sensors for airbags

Figure 3: Starter motor

Electronic systems: electronic systems which have the task of ensuring high vehicle performance are particularly important. Production and design are particularly aimed at components based on semiconductors, sensors and microelectronic devices. Of strategic importance is the integration of these products into modules and systems. DENSO can count on a great experience gained over the years thanks to the development of electronic control units for engines, control panels and finally control units on the bodies and other systems for the vehicle.

Figure 4: Panel board

Thermal systems: heating and cooling systems for cars are produced (Figure 1.4), which include air conditioners and radiators. The development of ecological equipment for domestic use is also very important.

IT systems: production is almost exclusively dedicated to satellite navigation systems.

Small engines: the Asmo CO. Ltd, part of the DENSO group, has the task of producing small engines in collaboration with the other automotive sectors of the same company. Particular attention is given to the motors for the windscreen washing systems the fans and the sensors.

Figure 5: Windshield washing system

INDUSTRIAL SYSTEMS:

DENSO WaveI corporate: it is a company that is part of the group and is focused on creating industrial systems that have the task of contributing to improving the productivity and efficiency of manufacturing systems.

DENSO Wave: it is mainly dedicated to the production of systems for electronic reading and identification, such as bar code readers, electronic identification devices. In 1994 he invented the QR Code to track car parts in Toyota factories. Given the code's ability to hold more data than a barcode, it was later used by several industries for inventory management. DENSO Wave also deals with industrial robots and more

2.2 DENSO THERMAL SYSTEMS

DENSO Thermal Systems S.p.A. was established in 1987 as MagnetiMarelli Climatizzazione at a time when the Fiat Group and MagnetiMarelli decided to enter the growing car air-conditioning industry.

In 1990 a joint venture was set up with DENSO Corporation (Nippondenso, at the time), world leader in the industry, leading the company into a phase of rapid growth with a build-up in R&D structures, producing technologies and competencies, a stronger presence in European Markets and growth and expansion in activities and production facilities.

In 2001 DENSO acquires full ownership of the Company that adopts the name DENSO Thermal Systems S.p.A.. This allows the company to become a fully fledged part of the Group, world leader in the field of automotive thermal systems.

DENSO Thermal Systems S.p.A. designs, develops, manufactures and sells air-conditioning systems, engine cooling systems, heat exchangers, radiators and compressors for cars, commercial and industrial vehicles and also for tractors, earth moving machinery, busses etc. It is also active in designing and assembling integrated cockpit and front-end modules for cars.

DENSO Thermal Systems S.p.A. designs, develops, manufactures and sells air-conditioning systems, engine cooling systems, heat exchangers, radiators and compressors for cars, commercial and industrial vehicles and also for tractors, earth moving machinery, busses etc. It is also active in designing and assembling integrated cockpit and front-end modules for cars

.

2.3 LOCATION

DENSO Thermal Systems S.p.A. headquarters are in Poirino (Turin), covering an area of 11800 sq. m. hosting the Company's Top Management, Administration, Engineering, Testing and an important production factory with over 1,600 employees. Production takes place in two other plants in Italy: Avellino and Cassino (Frosinone) and in a newly established Business Unit in Carmagnole, 15 kilometers away from Poirino.The Avellino plant, with over 900 workers, supplies Fiat Auto factories in the Centre-South of Italy and produces air-conditioning units, engine cooling modules and heat exchangers with the latest technology.
The Cassino plant, located within the premises of the Fiat Auto plant, was created for the in-house assembly of front-end modules for the Fiat Stilo model and employs some 100 workers. The Carmagnola Business Unit is a strategic project of the beginning of 2004. The new plant is totally dedicated to the sale of components to the independent spare parts market.

DENSO Thermal Systems S.p.A. also has its own plants in Portugal, Poland, Argentina, Brazil and India. A new plant is being built in Spain in the town of Vigo (Galicia) for the production of air-conditioning systemsto be sold to local car manufacturers (Peugeot/Citroën and Opel).

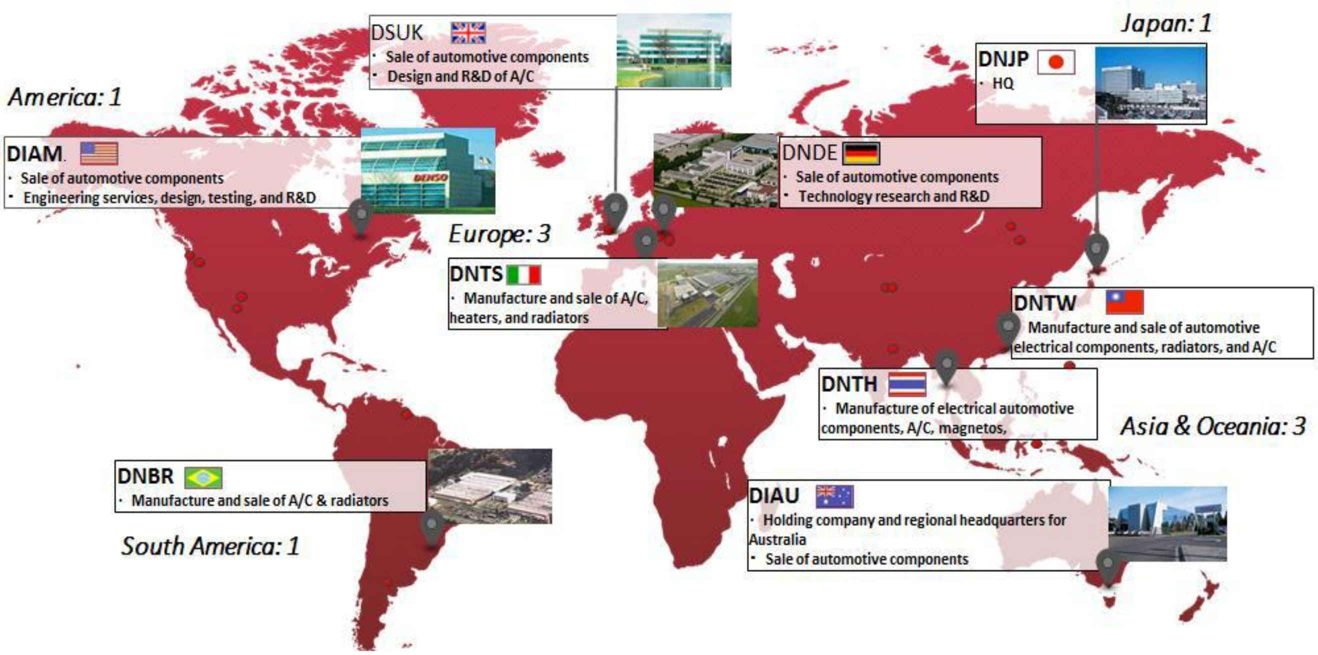


Figure 6: Denso in the world

2.4 DENSO-TS MARKET

The company is constantly expanding and growing and concentrates its research and product development activities on continuous innovation and constant attention to quality. DENSO Thermal Systems S.p.A. supplies its products to major automotive manufacturers including: Alfa Romeo, Audi, Citroën, Fiat, General Motors, Iveco, Lancia, Maserati, Mercedes, Opel, Peugeot, Renault, Scania, Seat, Toyota and Volkswagen and also Caterpillar, CNH Case New Holland, Lamborghini, Massey Ferguson, Piaggio.

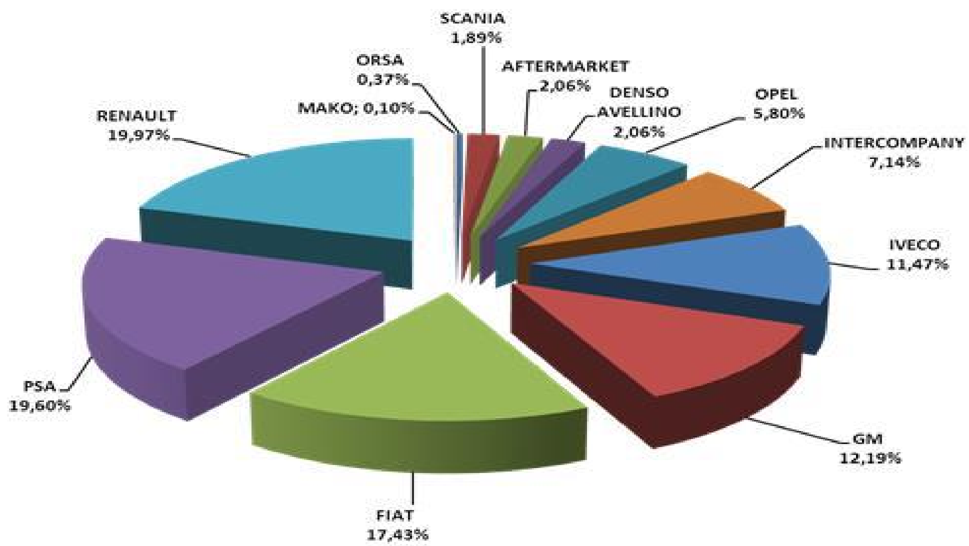


Figure 7: Percentage of sales per customers

In DENSO Thermal Systems S.p.A. at the base of every product development activity is the objective of anticipating the customer's needs. It should not be forgotten, however, that over the years there has also been an increase in competition, making it necessary to continuously improve quality, reduce the LEAD TIME of new products, ensure maximum timeliness and production flexibility.

Figure 8: Customers of Denso Thermal Systems

2.5 PLANT OF POIRINO

In Poirino a whole series of different services are grouped such as: production, R&D, sales organization and the whole structure for tests and development (wind tunnels).The industrial area covers about 118,000 m2. Like any modern large-scale industrial plant, the Poirino plant is divided into operating units, each of which produces the

details for the air conditioning and engine cooling systems

We analyze in detail the individual operating units: details for the air conditioning and engine cooling systems

1. Injection molding: all parts in thermoplastic material are produced such as: fans, centrifuges, radiator tanks, interior controls. It consists of three types of molding presses: large, small, bi-injection.

2. Pipes and fittings: this operating unit deals with the production of aluminum pipes and fittings that serve as a link between the various heat exchangers and the refrigerant circuits mounted in the car.

3. Nocolock Condensers and Radiant Masses: this is the most interesting and difficult part of the company management. Heat exchangers are produced whose packages are "held" together by the use of chemical binders that are grafted during the brazing process. The name Nocolok is precisely the patented name of this brazing process.

4. NocolokRadiatori: it is based on the same technology described in point 4.However, the U.O is dedicated to the production of radiators only

5. Assembly: here the various components coming from the other operating units are assembled to form thermal assemblies already assembled, to be then sent to the customer so that the latter has only the task of mounting these modules on the car.

6. Compressors: it is the flagship of the company. In a specially air-conditioned room the air conditioning system compressors are assembled. The components come mainly from Japan.

7. O.R.S.A: it is the youngest operational unit, independent of the other units, it deals with the air conditioning of buses, agricultural vehicles and construction site. Given the low production rate required, it is one of the least automated operating units to cope with the great diversity of models

2.6QUALITY IN DENSO THERMAL SYSTEMS

DENSO is constantly engaged, not only in the achievement of ambitious quality objectives, but also in implementing all the initiatives leading the company to achieve levels of excellence in all its activities. For DENSO, total quality first and foremost means complete Customer satisfaction.

The collaboration of every single person in the company is needed to attain this target; it is in fact obvious that all the Functions are involved in striving to achieve quality, both for external and internal customers, the latter being our colleagues. The underlying principle of all the activities of people working for DENSO is that of being "Driven by Quality": not just the quality of the products coming out of our factories, but also Quality in customer service, that is, quality in all that surrounds the product.

In this view, Management acts as a guarantor to the Customer, for the attainment of the objectives that lead to his complete satisfaction. The Quality department is present and active in all processes: from design and product development, to industrialization; from the creation of pre-series to production, up to services and after-sales activities. All this through continuous collaboration and shared initiatives with customers and suppliers. DENSO has set out to become “Leader in Quality” and is pursuing this objective through:

- motivation and involvement of Human Resources,
- inter functional team work,
- Widespread training at all levels,
- Promotion and dissemination of a “continuous improvement” mindset,
- Partnership creation with customers and suppliers,
- Creation and maintenance of a Quality System which anticipates and exceeds the demands of our customers and ISO 9000 quality Standards (in particular, technical specification ISO TS 16949).

Implementing Quality is the best way to conquer and maintain the trust of our customers, control our processes and guarantee our future.
This is why DENSO assures its customers rigorous and constant engagement on the part of its employees and continuous quality innovation to prevent problems and make sure things are done the best way, the first time.

Chapter 3

The Thermal System: what it is, the components and how it works

3.1The interior thermal system

First of all it is important to have a clear difference between a system and a module. A system is a set of components, arranged in the car even in non-contiguous places, which interact with each other to achieve a specific function (they are rigid). A module is a set of components and subsets that can be pre-assembled as a single unit, which is subsequently mounted in the vehicle.

The thermal-passenger compartment system in a vehicle allows you to control the climate comfort of the passenger compartment. Comfort includes all the parameters that influence climatic well-being and air quality. For this reason, these systems are equipped with filters, air purity sensors and air purifiers.

The main functions are:

Figure 9: Functions of the interior heating system

A cabin thermal system is composed of:

- Compressor;

- Evaporator;

- Capacitor;

- Filter;

- Pipes where the refrigerant gas flows;

- Radiant mass;

- HVAC module;

In this section the object of investigation will be the condenser. In fact, we will analyze not only the production process but, thanks to a careful process / product analysis, all possible causes of non-compliance that determine the waste.

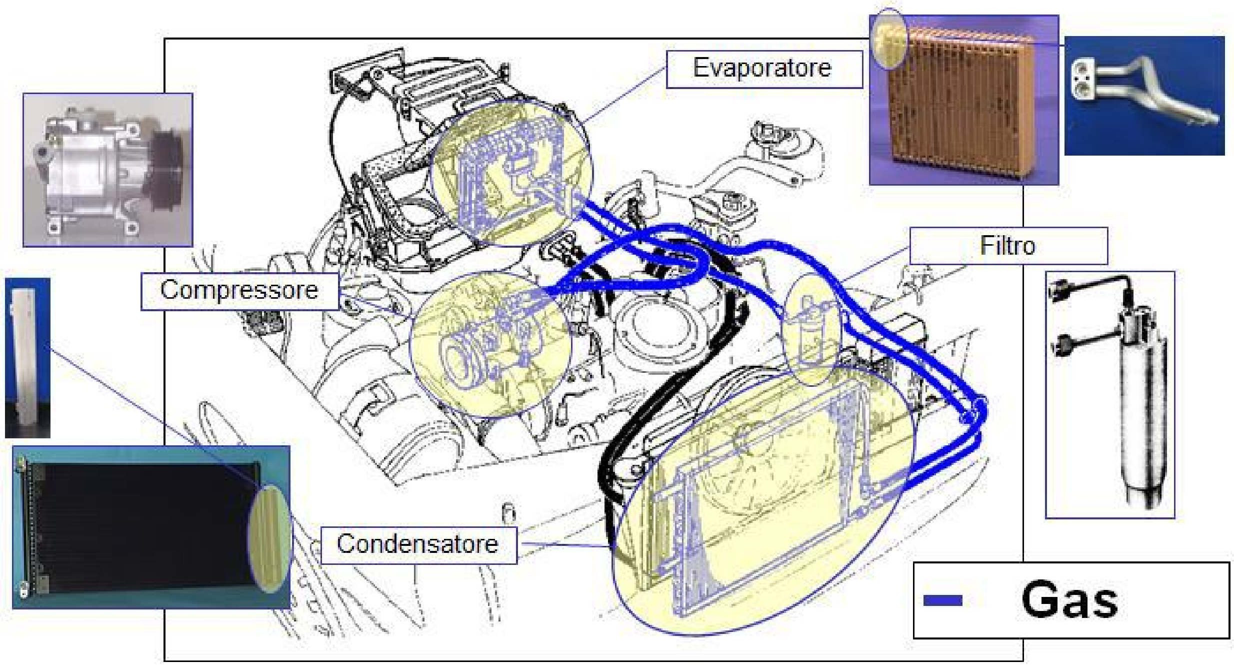


Figure 10: Scheme of a cabin thermal system

3.2 General information on cooling systems

The operation of a cooling system is based on the ability of substances to change their physical state if subjected to changes in pressure and temperature.

An example of state variation with subtraction or heat input is given by water, which at 1 bar pressure if cooled down to 0 ° C starts solidification which will lead it to turn into ice. At the same pressure, at 100 ° C the boiling starts turning into steam (Figure 2.2).

It is therefore clear, at this point, that the solidification and evaporation temperature characteristic of each substance is influenced by pressure.

The operating cycle of a cooling system is based on raising the pressure of a gas and its consequent condensation in the liquid state with the transfer of heat to the outside; subsequently induced to expand, it will return to the gaseous state thus absorbing heat from the environment to be cooled

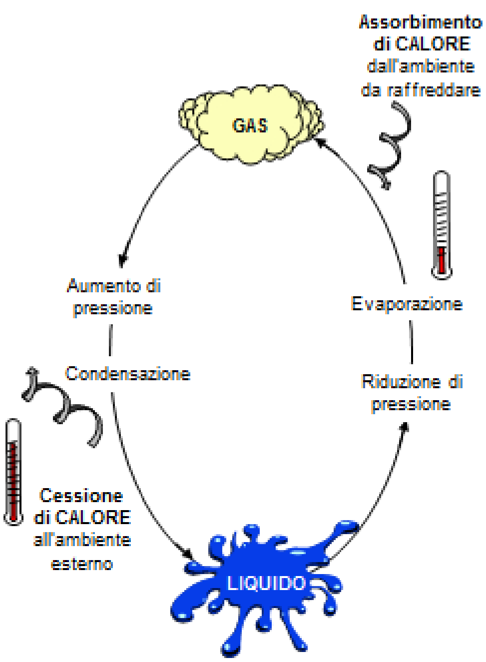


Figure 11: Refrigerator cycle

3.3 The condenser what it is and how it works

A condenser and a heat exchanger that has the purpose of absorbing heat gives an environment at a low temperature and yield it at a higher temperature .For this to happen, it is necessary to provide the plant with certain power. . This power is provided by the compressor, which subtracts from the one generated by the engine.

The essential components of the refrigeration system are: the compressor, capacitor, expansion valve, evaporator and integral filter.

Compared to the past today, the number of vehicles that mount the air conditioner is notoriously increased since the DENSO-TS has been constantly approaching migration, it has been producing at the end of the year a trade-off performance-consumer service that is always migratory in time.

The following will illustrate the operation of a climate control facility but it may concentrate on its condenser.

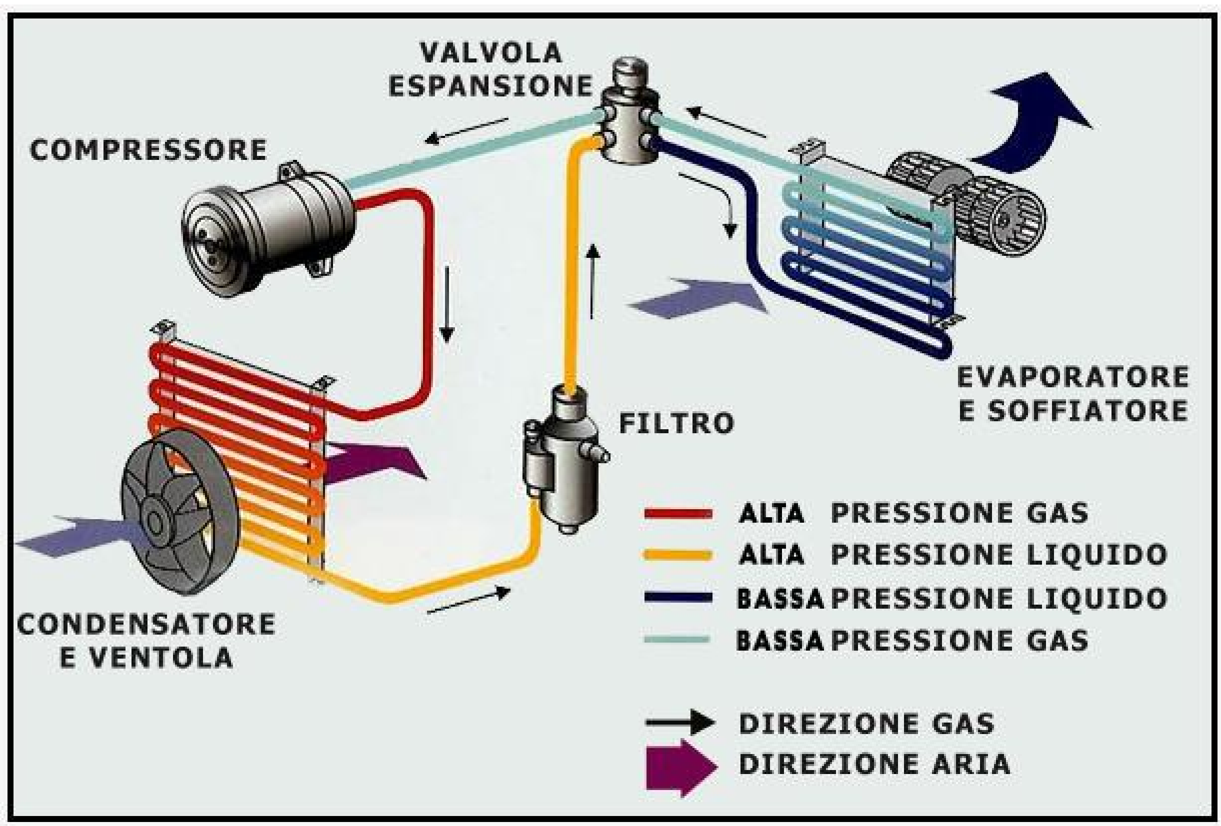


Figure 12: Scheme of an air conditioning system

The condenser is part of the front module which integrates the engine cooling module consisting of: radiator, condenser and axial electric fans, with a series of additional components usually arranged on the front of the vehicle.

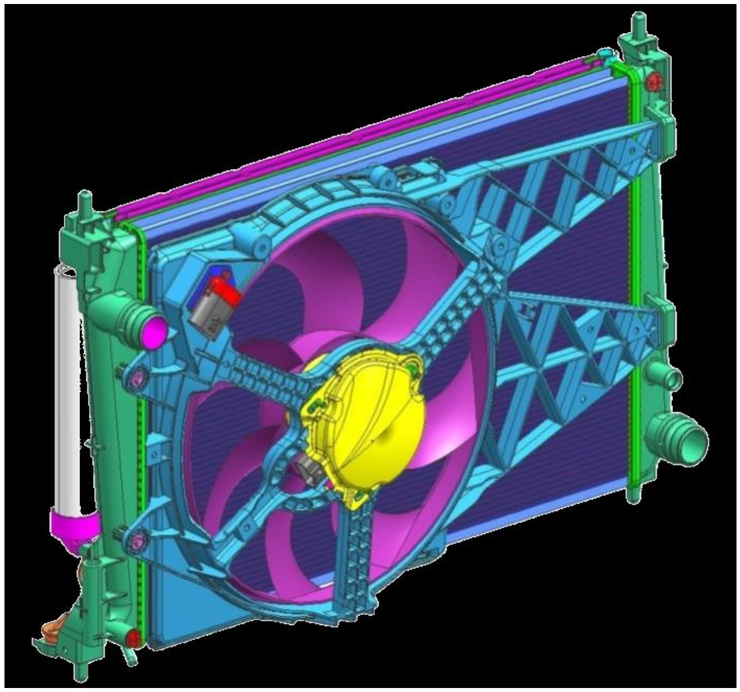


Figure 13: Frontal section

The evaporator is inserted in the air conditioning unit, generally installed (in whole or in part) in the vehicle interior and part of the dashboard module. The compressor, almost always installed on the thermal engine by means of a fixing flange, is mechanically dragged by the motor through a transmission belt that transmits the motion to all the auxiliary organs.

We can imagine the air conditioning system divided into two circuits: a high pressure circuit and a low pressure circuit.

In the high pressure part of the circuit, the refrigerant gas is compressed in the liquid state, transferring heat to the outside. In the low pressure part of the circuit, the refrigerant gas undergoes expansion by absorbing heat from inside the passenger compartment

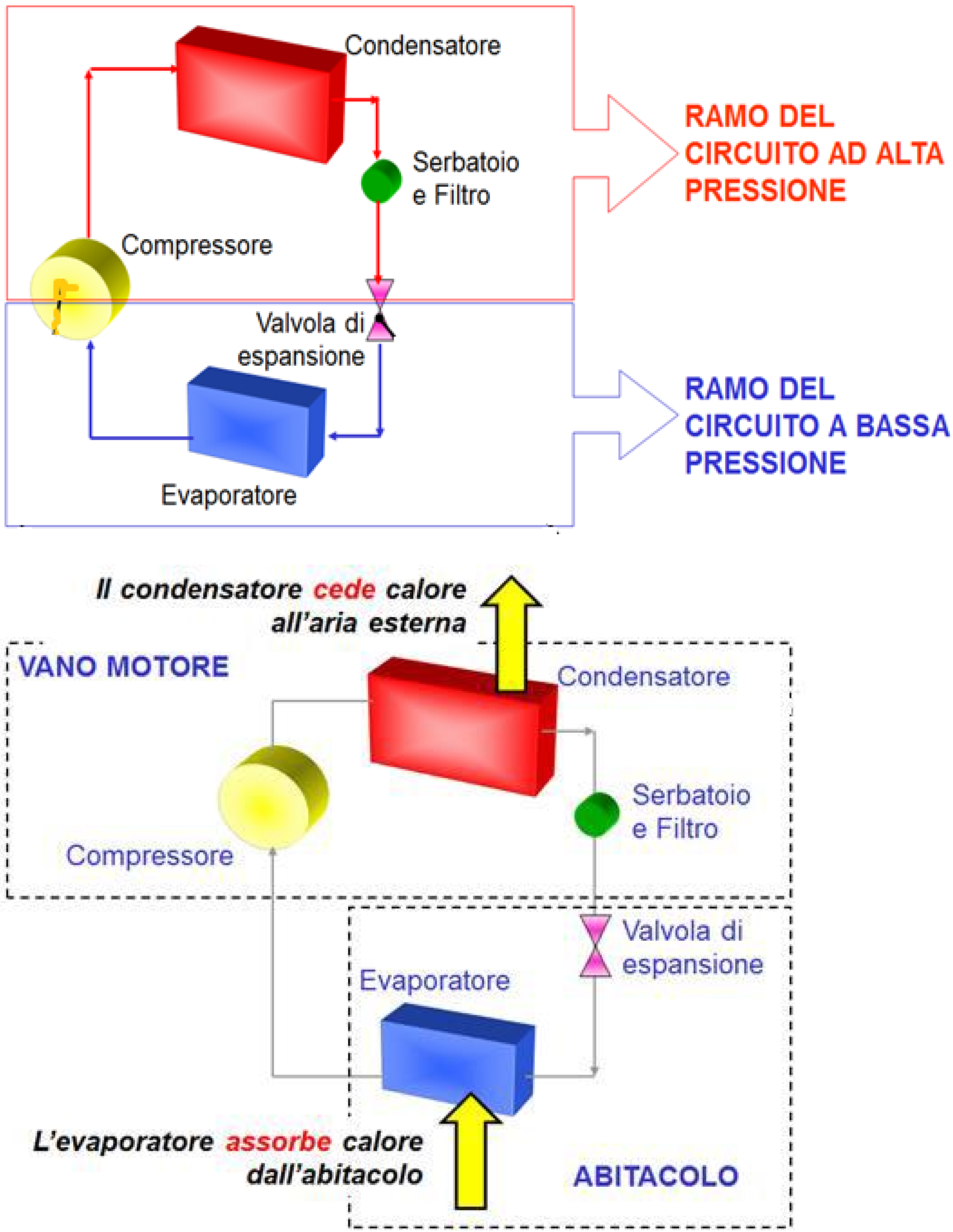


Figure 14: Operation of an air conditioning system

In the condenser, the refrigerant fluid (Freon R134 today; from 2016 HFO 1234 YF) that passes through the pipes transfers heat to the external fluid (air) that passes through the finned surface, passing from the gaseous state to the liquid state In fact, the fluid must be cooled at the compressor outlet, keeping the pressure constant (20 Bar).

The tube-fin contact is determined inside the brazing furnace where, at high temperatures, it melts the low-melting alloy of the fin plating and determines the contact. It is thanks to this contact that there is the exchange of heat between the two fluids (Gas-Air).

The air flow that passes through the finned surface is produced by the advancement of the vehicle or by a special electric fan which is fixed to the condenser itself.

The refrigerant in the gaseous state is forced to travel through the narrow and tortuous channels of the condenser. After passing the condenser, the gas, having condensed, arrives in the filter dehydrator in the liquid state and maintains this condition up to the expansion valve.

After the valve throttling, the liquid drops violently in pressure and temperature, expanding into the evaporator ducts, wider than the previous ones, absorbing heat to the ventilation flow directed to the passenger compartment. In this phase it evaporates completely returning to the gaseous state and is ready to be sucked in by the compressor and start a new cycle.

The evaporator is placed at the beginning of the ventilation system, downstream of the pollen filter of the internal fan. Its function is to subtract temperature from the direct air in the passenger compartment, while the air that passes through the exchanger is cooled, transfers part of its heat to the evaporator itself, also avoiding that the gas expanding inside can freeze.

In the circuit there is also a tank for the coolant which performs the function of "lung" and dehydrator filter. This component has the function of filtering any impurities of material removed by rubbing from the compressor or dirt resulting from assembly and at the same time retaining the humidity present in the circuit which could cause, being water, rust in some parts of the system.

Another system strategy should also be underlined, in other words the impossibility of turning off the fan with the compressor on, or of activating it with outside temperatures close to zero. All this is necessary to ensure a minimum heat exchange to the evaporator, which is essential to avoid the freezing of the gas inside and cause total blockage of the circuit. In order for the heat exchange to occur, there must be a thermal differential: the thermodynamic principle requires that the heat passes from the warmer body to the colder one and, the greater the thermal differential, the greater the exchange

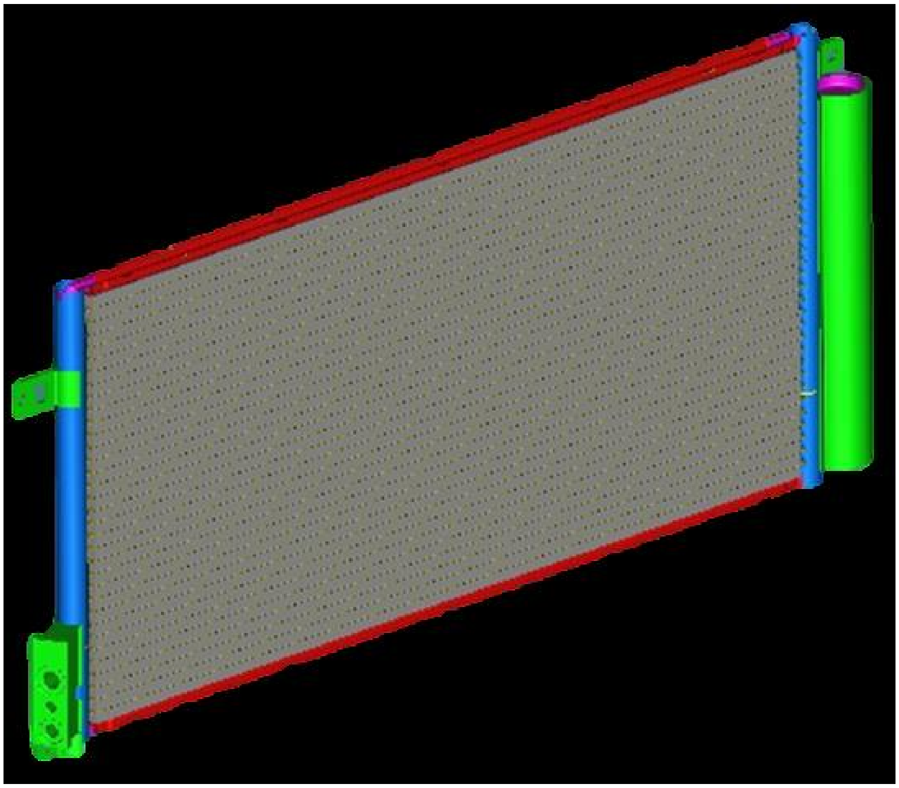


Figure 15: Brazed condenser

The current DENSO-TS production provides the brazed capacitor with the wire. The main advantage of this new technology is that all the components of a condenser are joined by brazing and not mechanically and that the Filter Body is integrated in the condenser.

A capacitor is essentially composed of:

- Multiport pipes;

- Distributors;

- Flaps;

- Sidewalls;

- Filter body

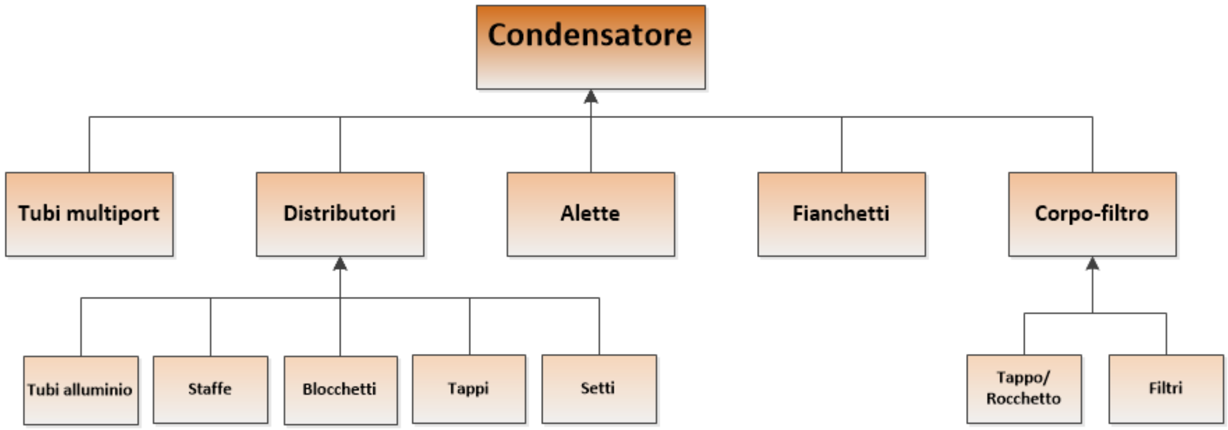


Figure 16: Components of condenser

We analyze every single component in detail.

Flaps: they have the task of improving the heat exchange between the fluid present in the pipes and the outside. In the condenser they also take on a structural function since it has the task of keeping the other components together.

The fin must have the largest possible exchange surface, have low thermal inertia and excellent dimensional accuracy (critical).

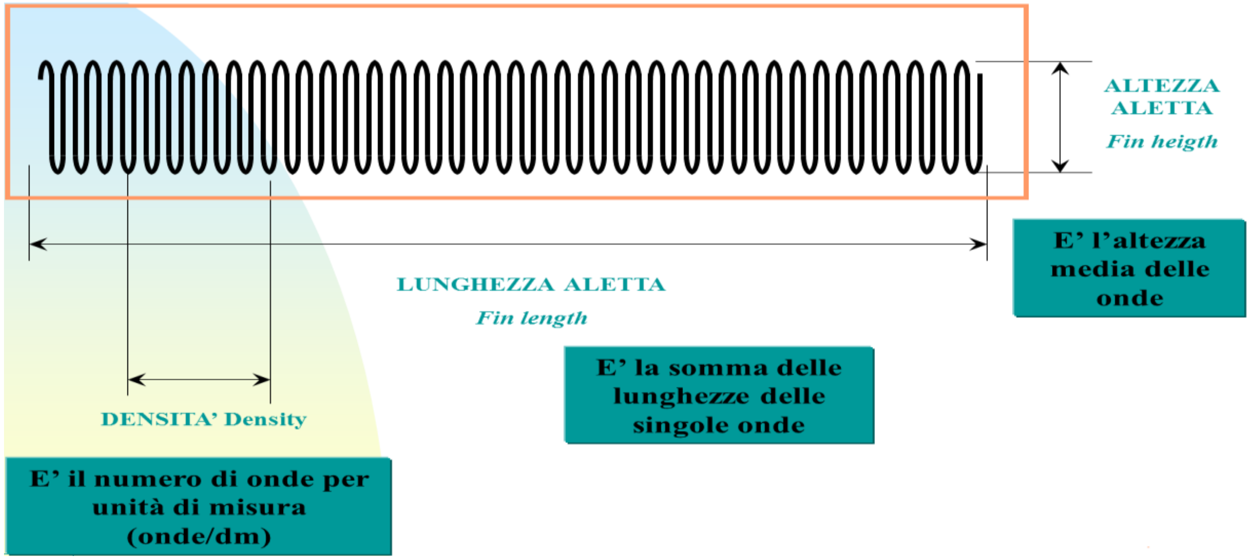


Figure 17: Fins section

Inside, the wave is made up of shutters (Figure 2.12). The shutters are incisions that serve to increase the turbulence of the air and therefore the heat exchange. The opening angle of the shutter and its length are very important for the heat exchange functions.

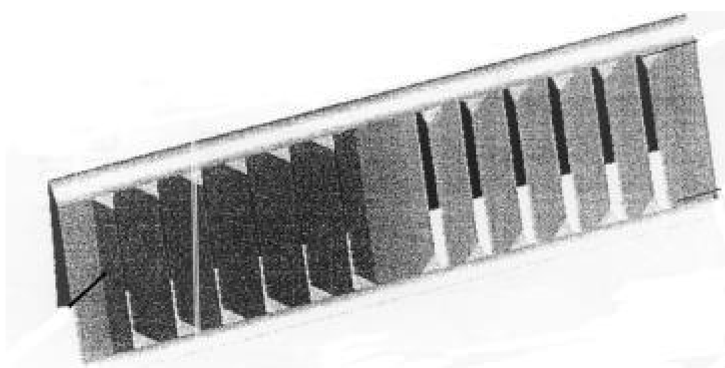


Figure 18: Shutters

Multiport pipe: the refrigerant gas flows inside it its particular geometry allows a better compression of the gas at the moment of its passage and a better heat exchange, with a consequent improvement of the performances.

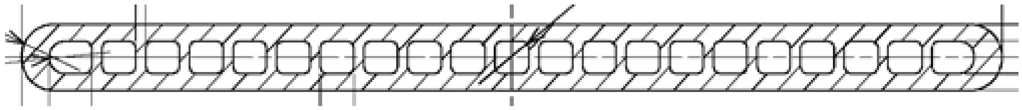


Figure 19: Internal section of multiport tube

The multiport tube on the sides is chamfered to allow easier insertion during assembly.

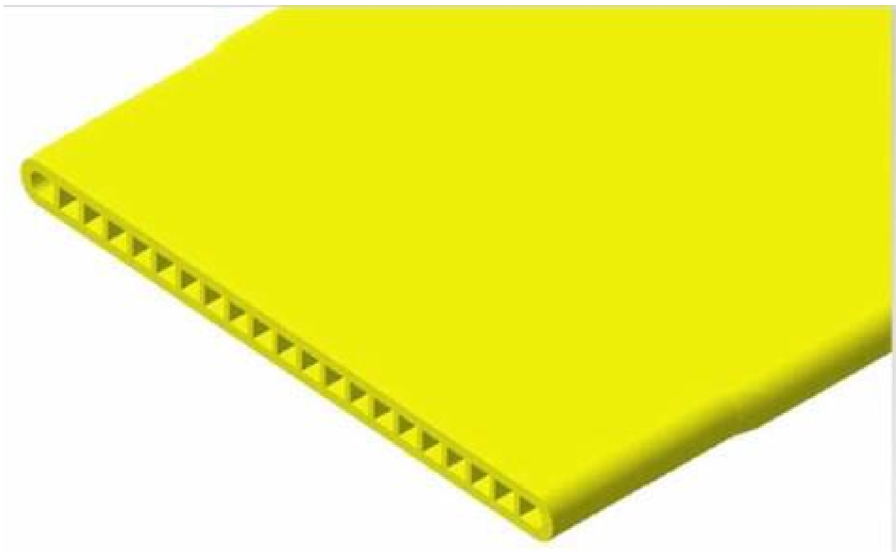


Figure 20: Multiport tube

Distributors: the distributor is an aluminum tube which, after having undergone several processes, allows the assembly of the pack. It is therefore the connecting element between the tube-fin bundles and the car. It has a dual function: structural and circuitry.

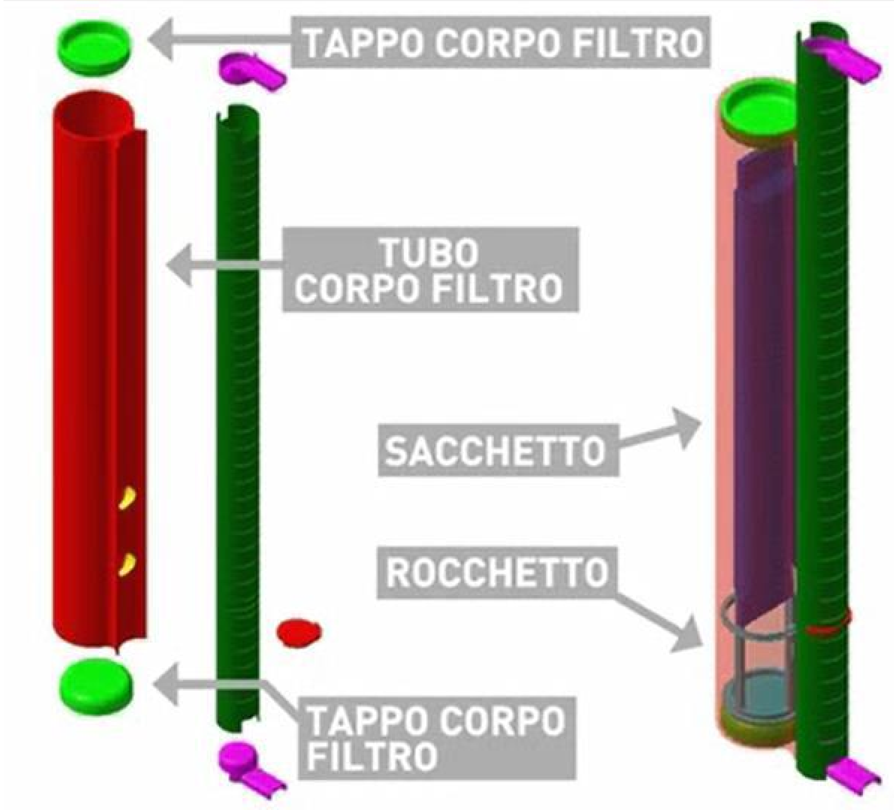


Figure 21:Distributor on the filter body side

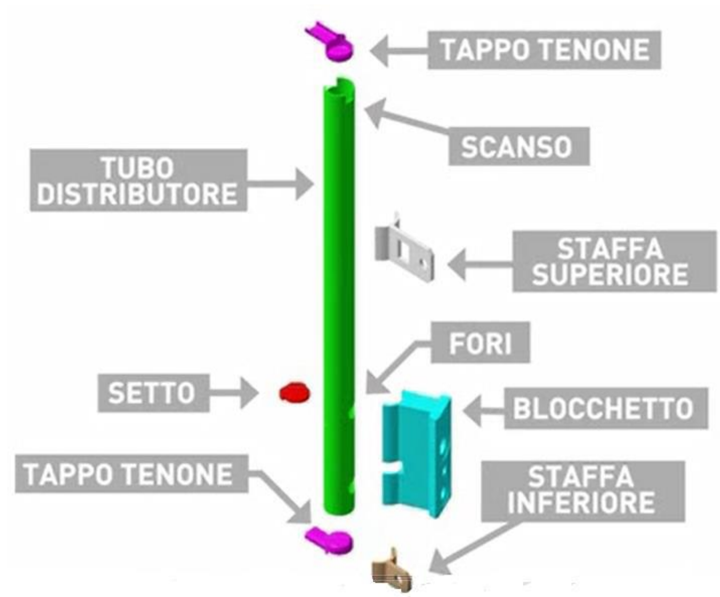


Figure 22: Block side distributor

The components that we can find in a distributor are:

1) Tenon cap: in addition to performing the function of capping the distributors, it also has a structural function, as it will support the side panels during assembly

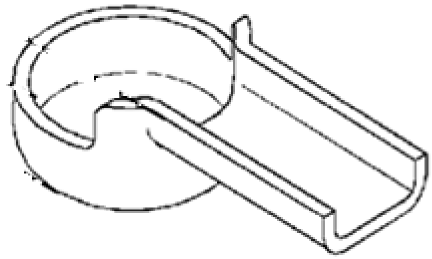


Figure 23: Distributor cap

2) Brackets: made by extrusion, they are used to connect the condenser to the car;

3) Extruded aluminum blocks: used to connect the condenser with the car circuit;

4) Filter body: made by extrusion, it performs three different functions:

- Contain a small mechanical filter to filter impurities;

- Contain the filter drier to eliminate the humidity that can slowly penetrate through the rubber sections from the vehicle's pipes;

- Create an accumulation of refrigerant to balance the circuit and create a supply that extends both the useful life of the system and the time before recharging;

5) Aluminum cap for some models;

6) Septa;

Furthermore, the filter body can be:

- Sealed: with a TIG welded aluminum cap;

- Not sealed: with a plastic cap, held by seger

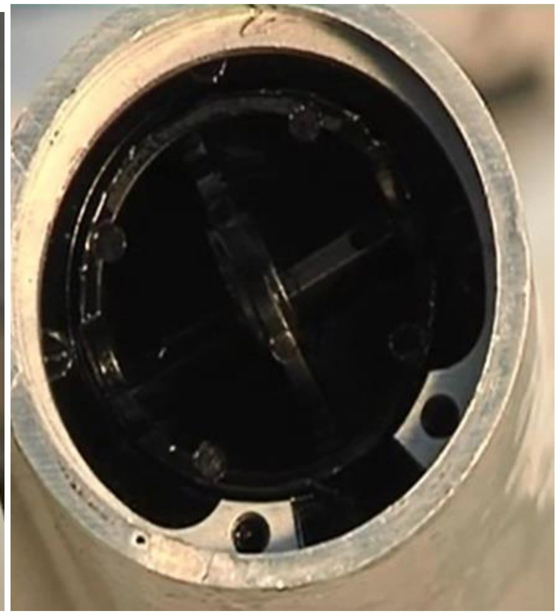


Figure 24: Sealed / unsealed filter body

Side: it has the task of closing the condenser on the sides (Figure 2.19). It is inserted after the last flap because it has the purpose of protecting it from knocks and deformations.

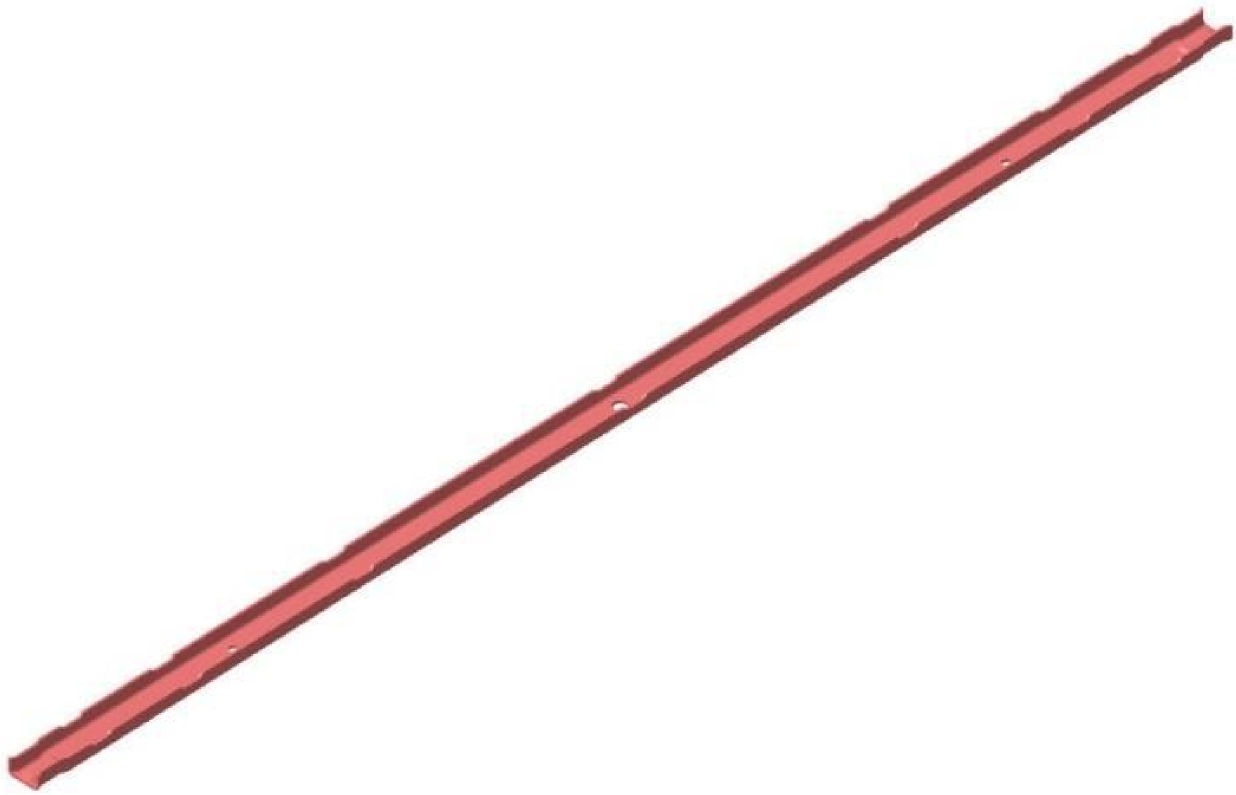


Figure 25: Fianchetto

Distributor side panel-cap joint: it has a structural function, since the junction of these two components assembles the condenser

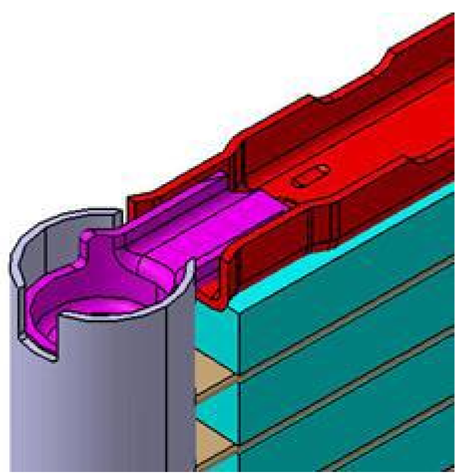


Figure 26: Side joint - Distributor cap

Filters: there are two types of filters, the particle filter and the dehydrator filter, both mounted on the condenser according to the model (Figure 2.21). The first has the task of filtering the gas before being introduced into the circuit; the second, inserted from above inside the filter body, has the task of removing the humidity present inside the condenser.

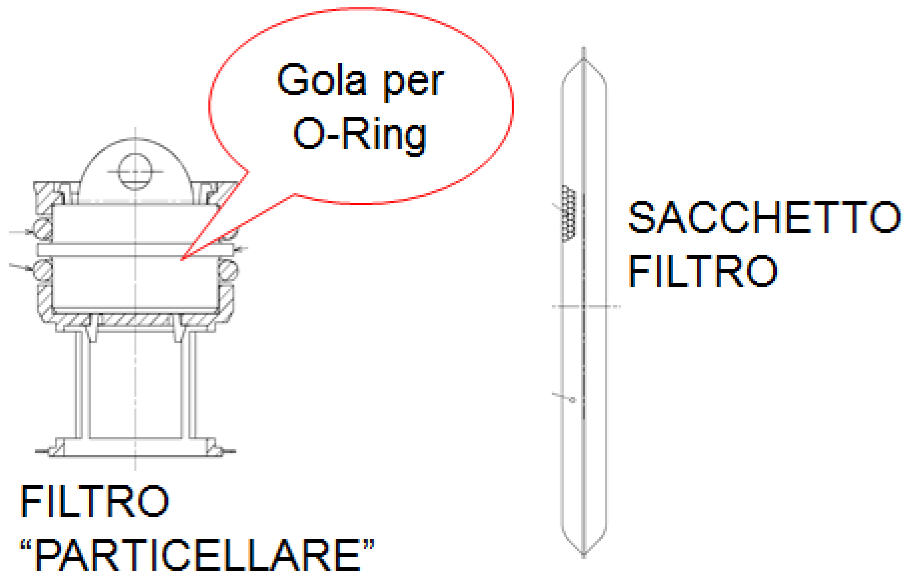


Figure 27: Filters

Process drifts in terms of performance, reliability and install ability

THE MAIN CAUSES OF DECREASE OF PERFORMANCE ARE:

- Less effective brazing (poor contact between tubes and fins);
- Poor opening of the louvers of the fin (poor air turbulence);
- Leakage from the internal septum (by-pass of the liquid flow);
- Step fins;

THE MOST FREQUENT CAUSES OF LOSS IN RELIABILITY ARE:

- Leakage from the cap-filter area due to the presence of flux on the O-ring seat;
- Loss due to badly performed brazing of the block to the distributor;
- Failure of the distributor in the area of the inlet block causes excessive stress from the layout-pipes coming from the compressor;

THE MAIN CAUSES OF PROBLEMS FOR THE INSTALLATION ON THE CONDENSER MODULE ARE:

- Excessive rotation of the distributors (position of brackets and blocks not in the drawing);

- Excessive deformation of the radiant pack;

- Presence of flux in the seats of the in-out fittings;

CHAPTER 4

CONDENSERS

4.1 PULL PRODUCTION

In DENSO-TS the production takes place in Pull mode, as only what is requested by the customer is produced in the times desired by the customer himself, with supplies of the components in Kanban. In the more extensive version, the Pull application is aimed at reducing, as well as eliminating, all forms of waste that occur within the factory in supply relationships. The main results deriving from all these techniques are:

- The decrease in inventory costs;
- Optimization of the production process;
- Increase the reliability generated by the increase in the quality of the process;

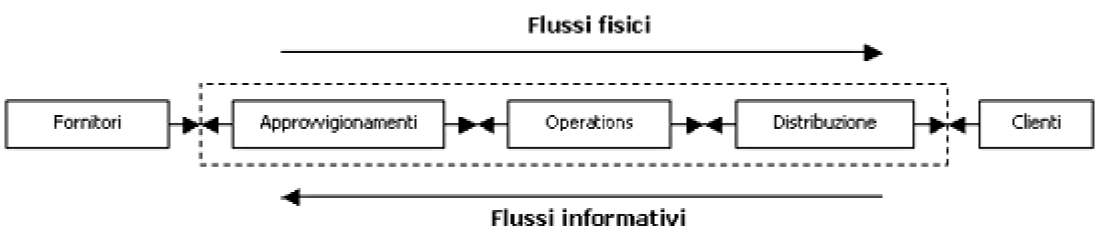


Figure 28: Pull Production

In the Pull philosophy, the physical flow (of materials) is opposite to that of information. The flow of materials represents the sequence of the process that goes from the raw material to the components, to the finished product, to distribution. During all these phases the product is given added value, thus increasing in value. The flow of information is different (what, how much and when to produce), which follows the opposite flow, starting from the customer to get to the supplier

At the moment I do not go further on what concerns the application of this philosophy. In section II I will deal fully with what the application of this method entails. Below is a detailed description of the production process of a capacitor: from the production of components to assembly to final testing.

4.2 PHASES OF PRODUCTION PROCESS

The production process of a capacitor can be divided into four main phases:

1) Preparation of distributors;

2) Assembly process;

3) Brazing process;

4) Sealing and final testing;.

4.2.1Distributors production process

A condenser consists of two distributors positioned on the sides: on one side we have the distributor-body-filter, on the other the distributor-blocks. Both will house the multiport tubes alternating with the fins and will aim to keep the condenser components united during assembly,

Figure 29: Distributore lato corpo – filtro

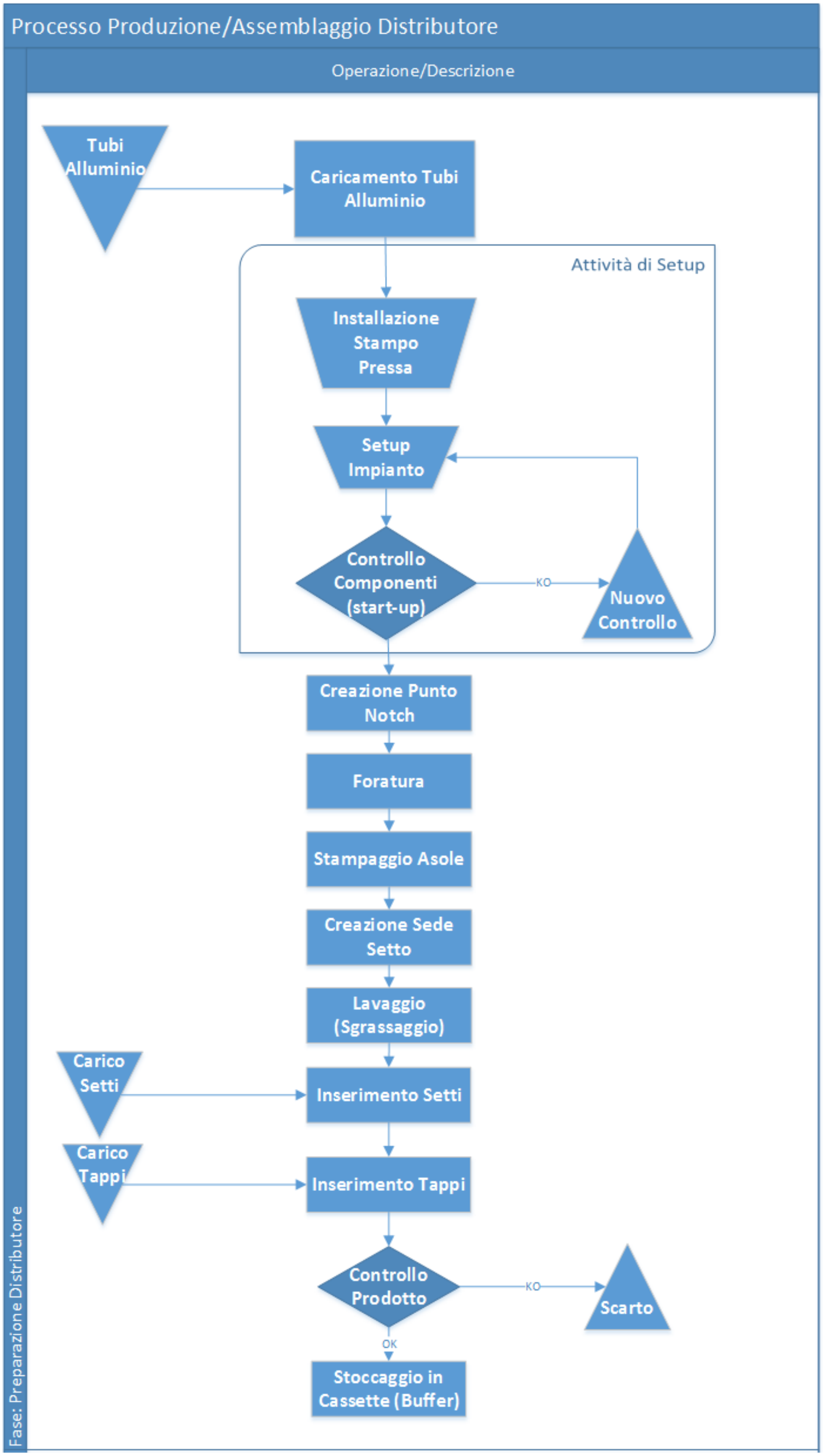
Figure 30: Distributorelatoblocchetti

The production process of a distributor takes place completely automatically and, for a clearer understanding of the process, the Process Flow Chart is shown below.

The following paragraph is intended to explain all the various stages of the process that lead to the production of a distributor.

Furthermore, the Setup activities were enclosed in a subgroup. Recall that the Setup activities are those of preparing the plant for the production of a specific model of condenser.

The process is divided into two parts: the first part consists of the production of the distributors and the second phase, of assembly, is used to obtain the complete distributor, with the blocks and the filter-body welded.


Processo Produzione/Assemblaggio Distributore
Operazione/Descrizione
Fase: Preparazione Distributore
Tubi Alluminio
Caricamento Tubi Alluminio
Attività di Setup
Installazione Stampo Pressa
Setup Impianto
Controllo Componenti (start-up)
KO
Nuovo Controllo
Creazione Punto Notch
Foratura
Stampaggio Asole
Creazione Sede Setto
Lavaggio (Sgrassaggio)
Carico Setti
Inserimento Setti
Carico Tappi
Inserimento Tappi
Controllo Prodotto
KO
Scarto
OK
Stoccaggio in Cassette (Buffer)

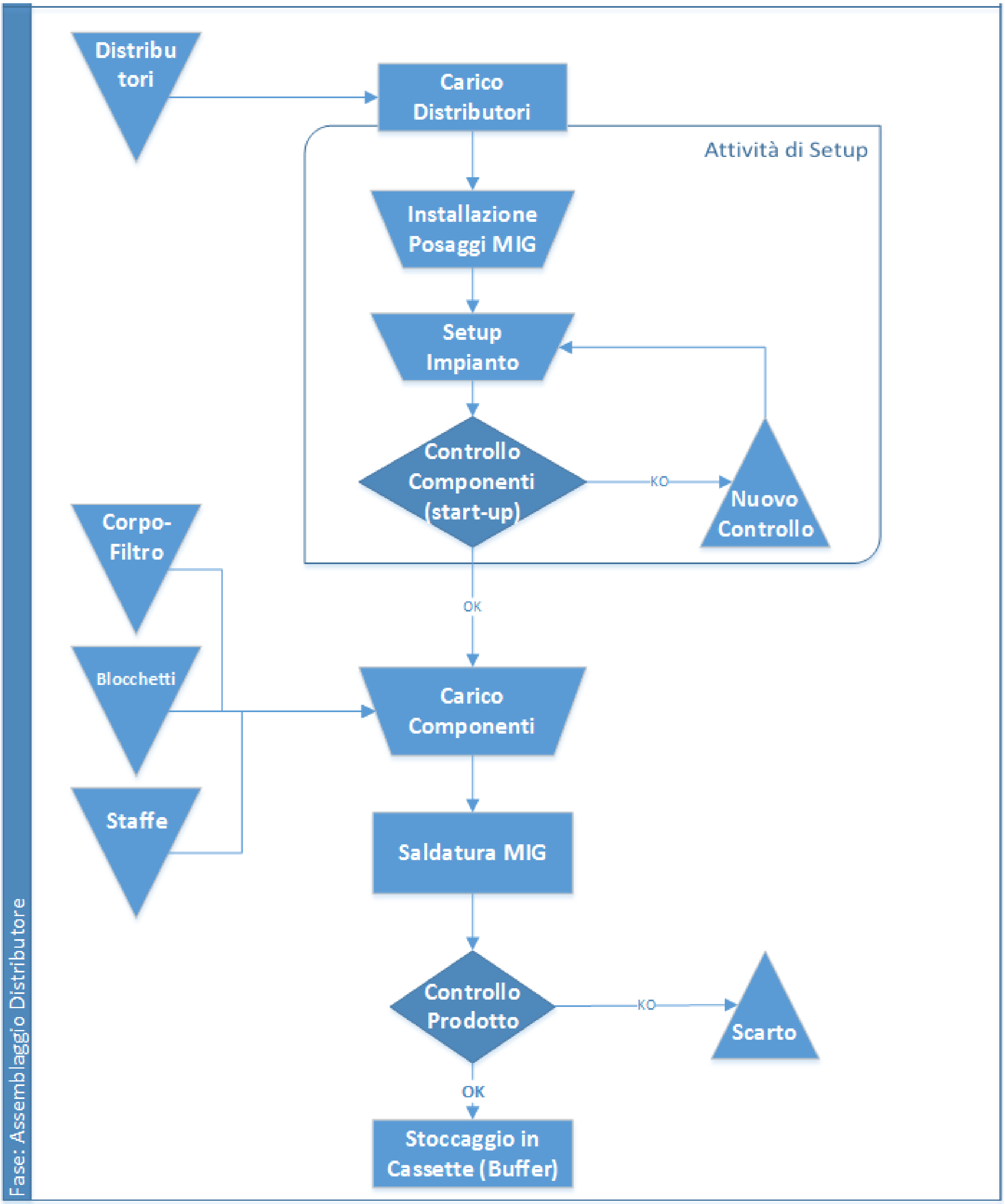


Figure 31:Flow chart

The first operations to be carried out concern: the preparation of the components necessary for production and the setting of the machine parameters which vary according to the model to be produced.

After that the system components and parameters are checked and, if they are incorrect, a new check will be carried out.

At this point the real production process begins where, once the aluminum tubes are inserted, a transducer checks their length. If the result of the check is positive, the Notch point is formed by shearing

The first operations to be carried out concern: the preparation of the components necessary for production and the setting of the machine parameters which vary according to the model to be produced.

After that the system components and parameters are checked and, if they are incorrect, a new check will be carried out.

At this point the real production process begins where, once the aluminum pipes are inserted, a transducer checks their length. If the result of the check is positive, the Notch point is formed by shearing

The Notch point is the reference point for the machine since the tube, being cylindrical, does not have a stop and therefore it is necessary to create it. At the same time, the "tenon-avoidance" is also formed for the insertion of the cap, always by cutting.

Figure 32: Notch Point

It then goes on to drilling by creating two holes in the tube at the height of which the blocks will be coupled in a subsequent phase, on one side and the filter body on the other.

Figure 33:Fori

Once the holes have been created, the distributor is ready for molding (by drawing in the vacuum) with the press, where the slots with the respective cusps are created. These will allow the insertion of the multiport pipes during the condenser assembly phase.

This phase is the one that allows the "circulation" (the flow of gas) with parallel beams in the condenser. The number of steps that the gas can make inside the circuit is variable and depends on the number of septa inserted in the distributor.

The subsequent processing consists precisely in creating the septum seat (using a saw blade) where the septum will be inserted, the number of which varies according to the model. In particular, the septum, being a component, is taken from the outside.

The septum performs the same function as a cap: it has the task of literally dividing the condenser into several sections to increase its pressure and therefore its performance. During this phase the distributor is also subjected to washing to eliminate the oil used in the molding phase of the aluminum tube.

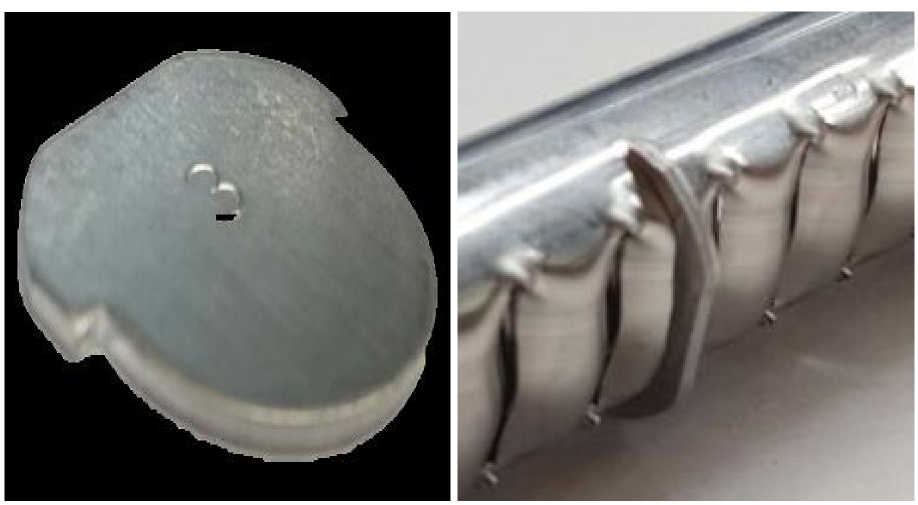


Figure 34: Seat-septum and septum

The septa are then inserted for "acciaccatura", that is for mechanical deformation, in order to create an interference between the septum and its seat.

Finally, tenon caps are also inserted. In addition to having the function of a cap, these will have the task of supporting the side panel during assembly

Figure 35: Tenon cap

At the end of the process the machine performs a quality control to verify that the piece is complete and there are no defects; otherwise the piece is discarded.The distributors that come out of the machine are arranged in boxes (buffers) to then be transported to the next stations, where the blocks and the filter body (M11 - M3 - M4) will be welded.

The distributor, at the end of this phase, looks like this:

Figure 36: Distributor example

At this stage, phase of the process consisting of MIG welding begins(Metal Innection Gas) of the IN / OUT blocks and of the filter body

This phase takes place on semi-automatic or automatic machines. Also in this case the first operations to carry out concern the preparation of the components necessary for the production and the setting of the machine parameters.The distributor and the components (Body-Filter, brackets, blocks) are positioned on "welding templates with placements" to correctly position the components, so as not to move during welding.

The machine then carries out the MIG welding which has the task of keeping the distributors assembled until the brazing process, where they will then be definitively joined.

Finally, the sample quality control takes place and, in the event of defects, the piece is discarded. The good distributors are stored in the boxes to then be transported in the assembly.

As can be seen from the figure, it is possible to distinguish the two blocks in the following way:

- Block IN: large hole;
- OUT block: small hole;

Figure 37: Block out and in

4.2.2ASSEMBLY PROCESS

The purpose of the assembly process is to join the various elements that make up the condenser. The components needed in this phase are: distributors, fins, multiport pipes and side panels. This type of processing takes place, for most models, in semi-automatic stations; only one model is produced in a fully automatic machine since the production volumes are quite high. The distributors have already been assembled in the previous phase; multiport pipes are an already finished external component like the side panels; the fins must be produced. A semiautomatic station is essentially composed of two parts: the first part dedicated to the production of the fins; the second dedicated to the assembly of the package.

The various stages of the process, essentially divided into two parts:

1) Fin forming and creation of the tube-fin sandwich;

2) Assembly of the condenser

Also in this case, for the Process Flow Chart, the legend of table 1 seen previously applies

PRODUCTION OF COILS

The fin forming process is a continuous mechanical deformation and cutting process using mechanical tools called rollers. For the production, aluminum coils with a thickness of 0.1 mm are used and the mechanical characteristics of elasticity and plasticity of the material are exploited. For any type of fin there is a single generally applied sequence (which we also find in the Flow Chart):

1. Solving of the material;
2. Belt tensioning;
3. Check voltage;
4. Lubrication;
5. Fin forming;
6. Flap compaction;
7. Calibration;
8. Cutting

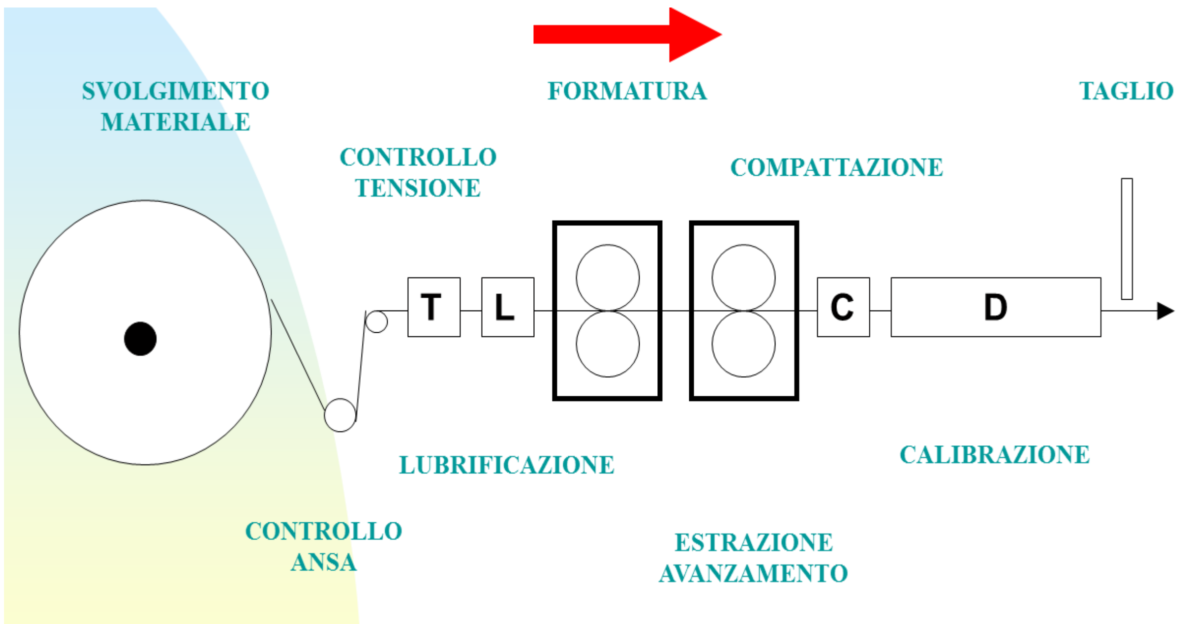
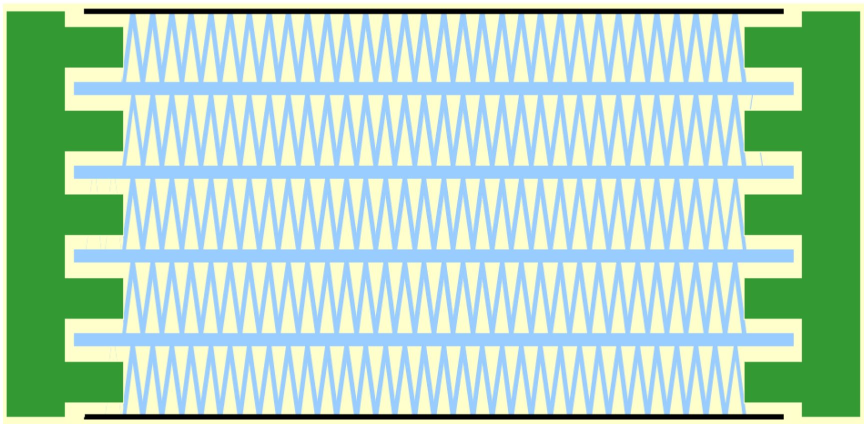


Figure 38: Fin formation process scheme

The process begins with the unwinding of the material (coils) using a conveyor, which can be single or double (to speed up the coil change). A voltage check is then carried out, a fundamental function to obtain the quality required by the fin.The system continuously monitors the amount of tape unrolled through a dancer, which has the task of adapting the speed of the conveyor to the speed of the machine and the progressive decrease in the coil diameter.

Lubrication consists in the application of oil to facilitate the forming process. It lubricates on the material and directly on the rollers. This is a very important step because the oil guarantees the good durability of the tools on the one hand, on the other it allows the belt to slide better on the teeth of the rollers and consequently adhere to them, for optimal control of the fin.The flap is formed by two rotating tools, called forming rollers, which form the flap and cut its louvers. This part of the process is the most important, the heart of the process itself. After the forming rollers we find the feed rollers, which have the function of extracting the formed flap and pushing it towards the next station in order to compact it.Compaction has the function of thickening the newly formed fin thickly, in order to prepare it for calibration. Once compacted, the flap is calibrated to the density required by the customer. The calibration takes place in the density stations, made up of pairs of motorized rollers that rotate at different speeds. Normally the first station causes an elongation of the flap, the second an adjustment.

Finally, the flap is cut to size by the cutting station. The cutting system is composed of a blade, which performs the actual cut, and a roller-scroll which guides the fin for a more precise cut and gives it a final final calibration. Condenser assembly In the assembly process we find: the fins, distributors, side panels and multiport pipes. The machine that performs the assembly function is the assembler. The assembling machine is automatically powered by the finisher and the tube loader and in some cases, in fully automatic machines, by the brazing brackets. The assembler automatically creates the correct tube-fin sequence, alternating them in order to start and end with a fin, as this structure is functional to the product project. Finally, it automatically transports everything to the assembly part



Then the operator manually loads the side panels and complete distributors. The post-assembly operation is the prestressing of the package between the side panels. The

Figure 39: Fin centering / pipe alignment

pack is compressed until the tubes and fins touch each other

4.2.3BRAZING PROCESS

Aluminum brazing is now the preferred process for the production of automotive heat exchangers such as radiators, condensers, evaporators and heater cores. Good corrosion resistance, formability and high thermal conductivity make aluminum an ideal material for the construction of these heat exchangers. Aluminum brazing involves joining of components with a brazing alloy that is an aluminum alloy (Al-Si) whose melting point is appreciably lower than that of the components. This brazing alloy is usually placed adjacent to or in between the components to be joined and the assembly is then heated to a temperature where the brazing alloy melts but not the components. Upon cooling, the brazing alloy forms a metallurgical bond between the joining surfaces of the components.

In DENSO-TS brazing with NOCOLOK flux is used. Flux is necessary because an oxide film is present on all aluminum surfaces, which must be removed in order for brazing to take place. the flux works by dissolving the tenacious oxide present on aluminum, and prevents further oxidation. The flux wets the faying surface of the components to be joined allowing the filler metal to be drawn freely into the joint capillary action. Upon cooling, the flux remains on the surface as a thin, strongly adherent film.

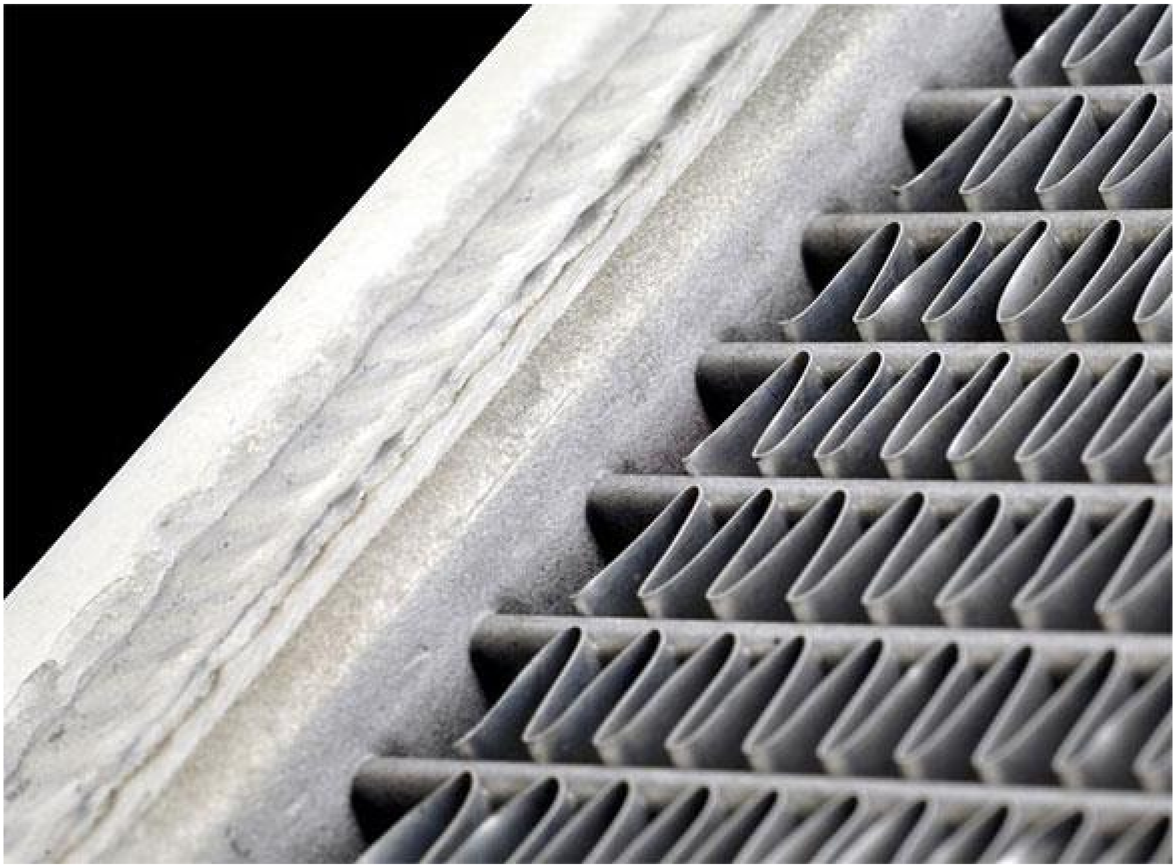


Figure 40: Brazing with nocolok flux

FEATURES & BENEFITS OF NOCOLOK BRAZING

- Improved Heat Transfer performance
- Pressure Drop Reduction
- Refrigerant Charge Reduction
- Reliability in Performance

* Recycling Advantages

* Noise Reduction

* Lower Weight

4.3 Sequence of the process

The brazing process consists of five main phases: thermal degreasing, fluxing, drying, brazing, cooling. The total time is about one hour

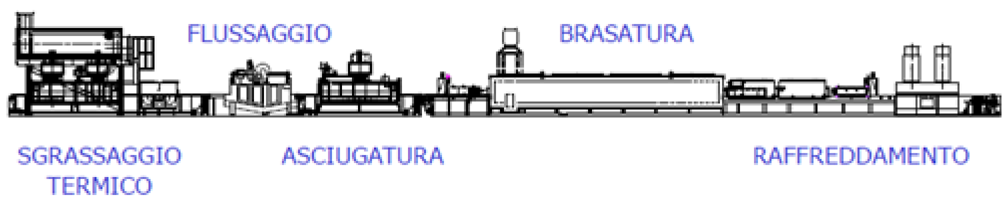


Figure 41: Brazing process sequence

Thermal degreasing: occurs using special oils which evaporate when heated. These lubricants evaporate without leaving residues, the burnt oil fumes are completely oxidized above 600 ° C.

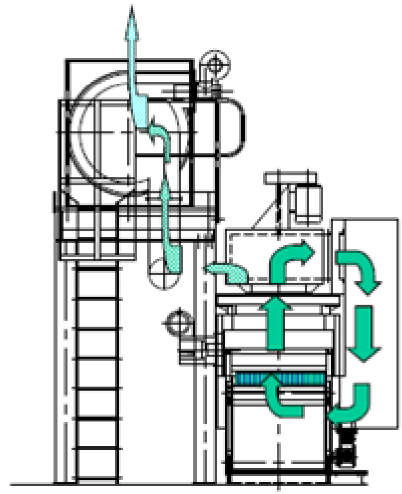


Figure 42: Hot air circulation

The condenser is inserted in a hot air circulation oven, the air passes through the piece from the bottom upwards, evaporating the oil.

Fluxing: the flux powder is dispersed in distilled water. The process in turn is divided into three stages:

1) Package flushing: the piece is sprayed with the suspension of flux;

2) Package blowing: the excess of flux trapped between the fins is eliminated;

3) Head flushing: the critical areas are flushed again;

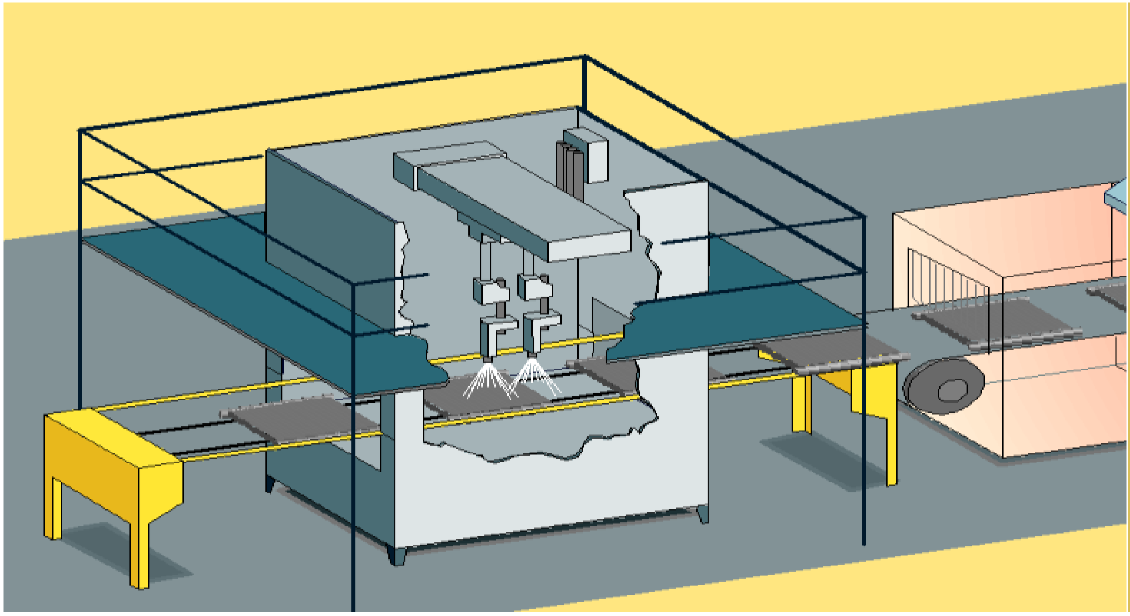


Figure 43: Flushing

Let's see what a condenser looks like after applying the flux:

Figure 44: Fluxed condenser

Drying: also in this case it takes place in a hot air circulation oven, the air passes through the piece from the bottom up.

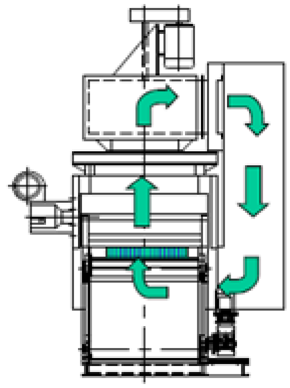


Figure 45: Hot air circulation

Brazing: brazing is the heart of the process and takes place in a brazing oven. The nitrogen atmosphere is created in a stainless steel "muffle" and the entry of oxygen is limited with stainless steel "curtains". The brazing temperature ranges from 590 to 610 ° C, with a heating rate of approximately 20 ° C / min.

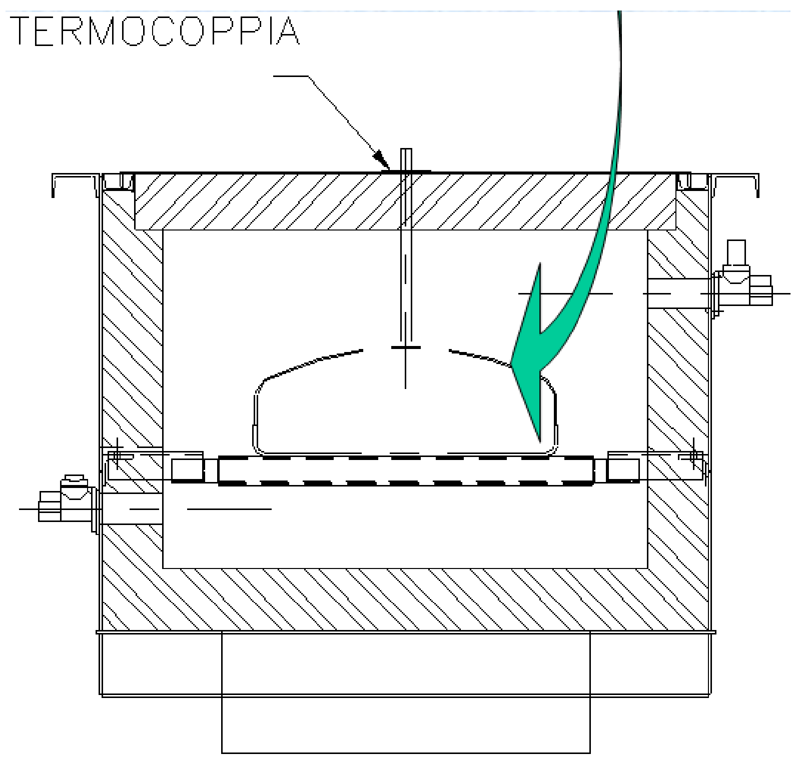


Figure 46:Particular steel "muffle" oven

La brasatura avviene in un forno di brasatura dove i materiali da brasare vengono trasportati su nastri in maglia metallica. Il funzionamento dei forni è di tipo continuo e possono superare anche i 30 metri di lunghezza.

Cooling: once out of the oven the piece is cooled. The first part of the process still takes place in a protective atmosphere, then in the air.

When leaving the oven, the piece is cold, and the operator removes the brazing brackets. In addition, the condenser withdraws due to the high temperature during the brazing process. If we measured the condenser before and after the brazing process, we would notice that the finished product is shorter by a few millimeters. For this reason the brazing brackets drop freely at the end of the process.

From an aesthetic point of view, at the end of the oven cooking process, the condenser is opaque compared to the beginning: in fact, during brazing, aluminum loses its natural brilliance. At the same time the brazing brackets slightly dirty the internal part of the condenser, for this reason the dirty part during assembly is turned inwards, because it is considered an aesthetic defect.

Process parameters

The brazing process is critical since the sealing of the piece under pressure depends on it. The joints to be brazed must have a solid joint and must not have non-brazed or badly brazed parts. In order for the brazing to be successful, there must be as little oxygen and humidity as possible inside the oven and the temperature must not drop below 590 ° C.

Important for the process are the following parameters:

- Temperature and time: if the temperature is low the flux melts, if the flux is high it erodes the metal. The same applies if the piece is too much / too little in the oven;

- Atmosphere: if there is too much oxygen in the oven, the aluminum oxidizes and brazing takes place only in the places where there is an excess of flux;

- Flux: if too little brazing does not take place, if too much brazing takes place but fluxing dirties the oven and the performance of the condenser decreases.

4.5 Final assembly and testing

In this phase the brazed condenser goes to the delivery state to the customer. The stages are:

- Pre-test
- Cartridge for unsealed condensers;
- Sealing for sealed condensers;
- Testing in helium;
- Marking and packaging;

The final output will therefore be the complete and sealed condenser

Pretesting

The pre-test is used to check the quality of the welding and assembly, at the level of the fluid-dynamic seal at low pressure (takes place in the air). The output is therefore the tested condenser.The pre-test operation is useful for discriminating macro-losses from micro-losses, due to previous operations. If we have any kind of losses, the condenser cannot continue on its path.

The operator introduces air into the filter body by pressurizing it to two pressure bars, and verifies that the pressure remains constant during the test. If at this stage the condenser is deemed non-compliant it is re-brazed or sent to the repair area

Cartridge

The cartridge phase is the operation after which the condenser is equipped with two internal accessories, thanks to which it can perform the function of gas filter that must cool. These two components are:
- Spool;
- Dehydrator filter;

The cartridge operation is applied in two different ways depending on whether the condenser is sealed or unsealed.
In the case of a sealed capacitor, the cartridge phase takes place through two operations:
- Inserting the spool;
- Inserting the dehydrator bag;

The two elements are therefore inserted into the capacitor separately

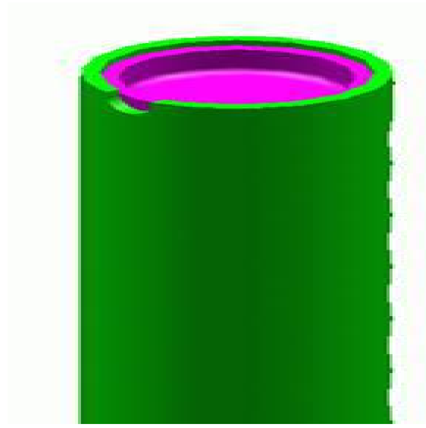


Figure 47O-ring

In the case of an unsealed condenser, the operation consists in inserting the spool, the dehydrator bag and the cap. The operator subsequently inserts the seger to keep the two elements in place, locking them inside the filter body.

Figure 48: Seger

The sealing operation also takes place in two different ways, depending on whether the condenser is sealed or unsealed.

If the condenser is sealed, the operation is carried out in two stages. The upper cap is inserted first, then TIG welding is performed.

If the condenser is unsealed, the cartridge is blocked with the seger, elastic metal ring, inserted automatically by the cartridge station.

Testing phase

It has the task of checking the tightness of the condenser. The output of this phase is the finished capacitor capable of performing all the functions for which it was designed.

The operator takes the condenser, inserts it inside the test bench, and connects it to the connections, then from the start. All the air is evacuated inside the test bench chamber and the condenser is pressurized with air to intercept the macro-leaks. If the first test in the air is positive, and there are no leaks in the air, it is taken and 30Bar helium is injected in its place. Within a predefined period of time, the helium units that are found inside the chamber are calculated.

If the test is positive, the component must be accompanied by appropriate identification labels. If, on the other hand, the test is negative, the condenser must be inserted between the pieces of waste and is accompanied by a special red waste label. All the operations described are performed by a single automatic line.

Testing takes place in a closed chamber for two reasons:

- To ensure that helium is from a leak;

- For safety reasons due to the high pressure reached;

Packaging / Packaging

At this point, plastic caps are inserted manually into the blocks, which have the task of not allowing impurities to enter the condenser circuit; a machine labels the condenser and an operator, before shipping the product, performs a very last visual check.

At this point the condenser is ready to be sent to the customer

The pieces are placed in a container intended for internal assembly lines or directly to the end customer who builds the car: the car maker

4.6 The repair of condenser

What does it mean to repair?

Not all pieces come out perfect from the production line. The goal of the repair is to recover or, at least, try to save the salvable.

Each piece of SCARTO has a cost:

- one or more people have used part of their time to assemble, braze, and test a piece that results in waste ⟹ waste of time and material!

- one or more pieces destined for the customer do not arrive at their destination but must be thrown away ⟹ production failure!

How do you create defects in a piece?

Couplings of two or more parts are not the desired ones and brazing cannot take place. This is because, in order for brazing to take place, there must be sliding of the filler alloy, but this can only slide and not jump. In other words, a too high joint will not be able to be filled by the alloy, and the so-called "brazing joint" will not be formed.

During the brazing process one or more defects in setting the oven parameters may be distorted, creating the conditions for ruining the brazing process.

During the assembly process mechanical defects can be created which ruin one or more components of the piece, causing the piece to require intervention to continue its journey.

It may be useful to repair a capacitor when:

1) During assembly, a capacitor can present problems;

2) At the exit of the oven, a condenser can have one or more non-brazed points;

3) Even with brazed in / out blocks, the condenser has localized leaks and therefore may require specific repairs;

Defect types analysis: Condenser in assembly phase

Damaged, short or collapsed fin

In this case, a banquet is used where the package is inserted so that it can be compressed, in order to disassemble it. Subsequently the brazing brackets are removed by recompressing the pack, the pack is then decompressed, in order to extract the fins and be replaced with the new ones. Finally, once the fins have been replaced, the pack is recompressed to insert the brackets and the pack is decompressed.

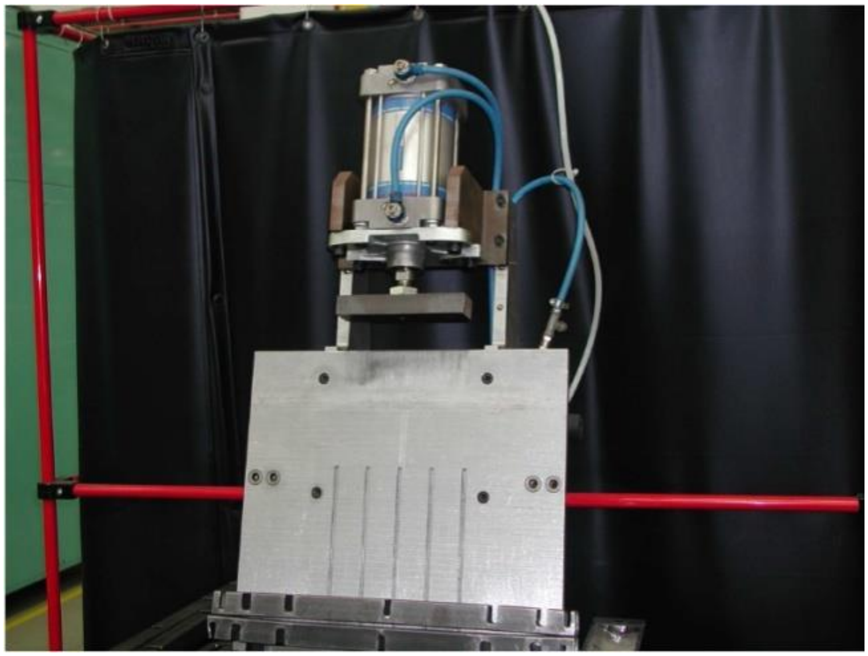


Figure 49: Repair bench

Figure 50: Example of short fins

Pipe collapsed, damaged or not planted

The banquet is used where the package is inserted so that it can be compressed in order to disassemble it. The brazing brackets are removed by recompressing the pack. The package is decompressed and the damaged tube is removed, which must be replaced with a new one. The tube is flared by hand in both directions to hold it in place. Finally the pack is compressed, the brackets are inserted and the pack is decompressed.

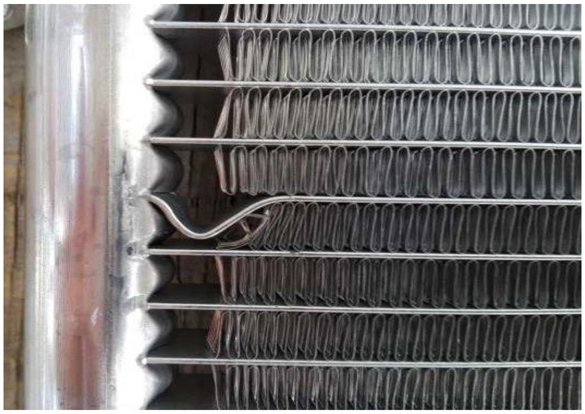


Figure 51: Pipe poorly planted

Damaged side

The banquet is used where the package is inserted so that it can be compressed in order to disassemble it. The brazing brackets are removed by recompressing the pack. The package is decompressed and the damaged side panel is removed, which must be replaced with a new one. Finally the pack is compressed, the brackets are inserted and the pack is decompressed.

Figure 52: Damaged side

Defect types analysis: condenser in brazing phase

Fin not brazed to the side panel or tube

The pack is passed back in the oven making sure that the necessary contact is made so that brazing can take place. The bracket is placed on the package at the point where the defect is highlighted and this is placed at an angle that creates a tension that compresses the package. At this point the pack is passed again in the oven by placing it on a special tray, making sure that the contact necessary for brazing is made.

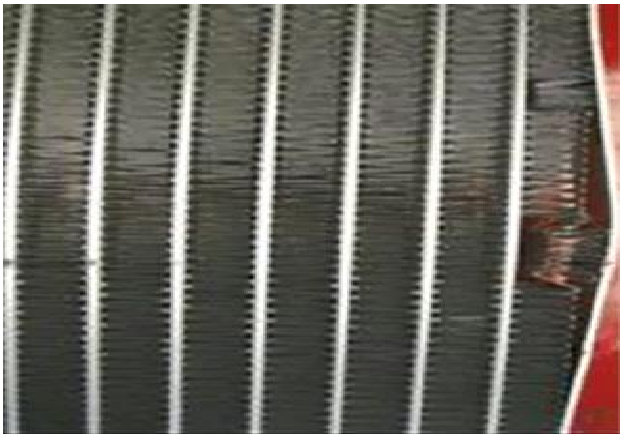


Figure 53: Side not brazed on the side

Leakage from pipes

In the event that the leak came from the pipes, the repair is done by re-brazing. The package is passed back in the oven lying on the contrary on the appropriate tray. In this phase there is no additional paste flushing to the pipes but it occurs normally.

Incorrect brazing due to excess flux

The pack is passed back to the oven on a special tray and normal flushing is maintained.

Incorrect brazing due to insufficient temperature (cold piece)

The package is passed through the oven on a special tray. In this case, further flushing is no longer performed since flushing of the first passage in the oven is already sufficient.

Localized defect on blocks

Flame repair: a repair is applied using Filalu rods (alloy rods with flux inside). By using these rods as a brazing filler material, there are two effects at the same time: that of the presence of flux and that of the actual filler material. The piece is heated by applying a direct flame to the leak point. At the appropriate T (565 ° C - 570 ° C), the flux already present on the piece from the previous passage in the oven is melted. Supply of the filler alloy with consequent melting and creation of the brazing joint.

Figure 54: Defects on the block

Localized defect on MIG points

It is a defect that is detected in a high porosity of the MIG point that penetrates deeply. In these cases, hand welding is carried out with pure aluminum rods.

Figure 55: Defects by welding

Defects on brackets and distributor caps

Repair is carried out using flame brazing with Filalu rods.

Loss of pipes in / out

Repair is carried out using flame brazing with Filalu rods.

GENERAL CONSIDERATION

Once repaired, the capacitor must be tested to verify the success of the repair.

A re-brazed condenser can be repaired, a repaired part cannot be re-brazed.

CHAPTER 5

WORK INSTRUCTIONS

5.1 INTRODUCTION

Every employee has a slightly different way of doing things. Each has a different background, different experience, different depth of skill, and a slightly different work process and that introduces variation into a company's workflow. The larger your operation, the more variation works its way into the production line.

The target is to make work instructions where complex processes looks simple. Work instructions may take a lot of time to plan and create, but great instructions will significantly benefit production. They are the pathway to incremental improvement the cornerstone of lean manufacturing. Our job was done by having direct contact with the workers in the production line in order to take direct information from the workers especially the team leader in order to analyze their work and to be able to proceed with the improvements needed taking into account the workers to be confident while doing their job where these instructions must be implemented in the production lines beside the workers in order to reduce the work variety between each worker so to increase the efficiency of the production line of the condensers, which will automatically enhance the percentage of the internal scraps in the company which will lead to cost reduction of the production, here we are talking about a closed cycle where at the first beginning will start with standardization and will finally give the results in terms of cost reduction so the company can make more products with less cost.

On the other hand having standards for all the production system in all its different phases, we can improve the quality of the finished products in order to have satisfaction of our customers which is one of the main goals of the quality which will lead to have more confidence between the company and our customers

The work instructions were done for all the phases for making the condenser which are:

1. Preparation of the distributor.
2. Assembly process.
3. Brazing process.
4. Sealing and final testing

5.2 STRUCTURE

The main aim is to make a structure which will make all the steps clarified for the workers and even for the customers

In this section we will show pictures of the division of the work instruction with explanation

The work instructions made were approved by plant quality responsible, Human safety engineer and from the production area manager. We have to indicate the name of the work station interested in, part number of each component, moreover we have to indicate which are the personal protective equipment needed (safety shoes, gloves, glasses and masks…)

DENSO	ISTRUZIONE DI LAVORO			ILP n° Rev A Data: **Compilato da:** Diab Ahmad
APPROVATO DA	**PLANT QUALITY:**	**PLANTI TIE:**	**HSE Responsible:**	
	P.E.AREA:	**PRODUCTION AREA MANAGER:**		
Titolo				Pag 1/N
Postazione di lavoro interessata				
Part number coinvoilti				
DPI (Dispositivi di Protezione Individuale)	**Scarpe**	**Guanti**	**Occhiali**	**Maschere**
			NA	NA

Figure 56: Approval and safety

Moreover we have to show a clear layout of the workstation and to insure the best layout to make the worker feel comfort during the passages and including all the movement that the worker have to make .Identify in the layout the places of all the materials and the instruments needed and we have not to forget in the layout to insure the the safety for workers for example by identifying the safety lines for each workstation)

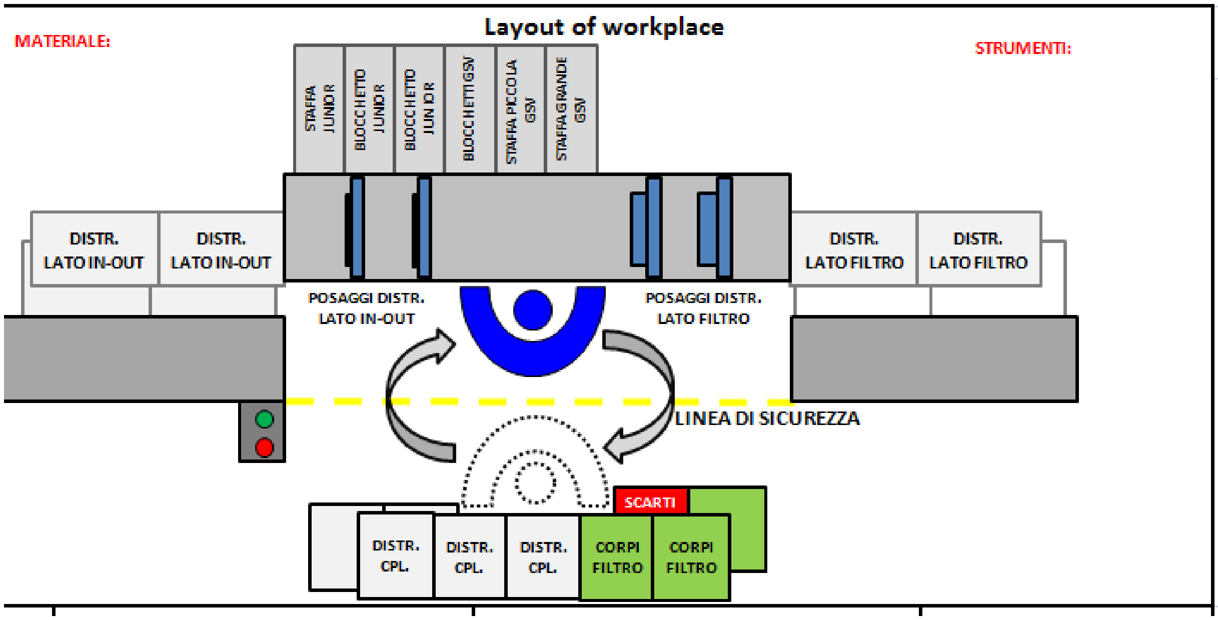


Figure 57: Layout

At this step we can start explaining the how the work phases we divide and the procedure for the explanation (FASI DI LAVORO)

The phases are divided into major steps, key point and key point reason (perche)

major steps: at this step we have to explain all the details in the phase including every move the worker have to make with a very clear way and after each description, photo must be provided key point

key point: we have to highlight to main steps from what we explained in the major steps, where the importance of the key point is to lt the worker concentrate in what is the most critical steps and where they have to pay attention the most. As the major steps also the key point is provided with clear photo after the test to make the worker work in efficient way.

Key point reason (perche): The main thing behind this step is to educate the worker, it is important to explain for the workers the reason of each step they are making so whenever they understand the reason, they will know the importance of the work they are making.

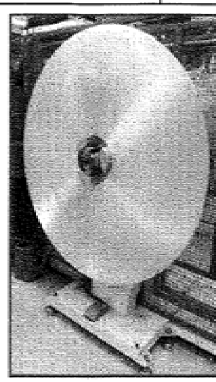
Fase	Operazione principale (major step)		Punto chiave (key point)		Perché (key point reason)
	testo	foto	testo	foto	
FASI DI LAVORO					
1					

Figure 58: Phases of work

After making all the steps for explaining the procedure needed, checks to be carried out in self-control by the operator and related criteria,(For frequency and measuring instruments provided refer to the control plan),

In this phase the worker have to check all the instruments used and make sure that they are in a perfect shape in order to complete all the procedure and after each check the worker must fill data sheet (scheda relieve dati) which will explain the situation of the instrument used.

DENSO DENSO THERMAL SYSTEMS S.p.A.	SCHEDA RILIEVO DATI	Elaborazione: C. Ferro Approvazione: S. Porpiglia Data: 24/04/2017
SCHEDA N° 7	DESCRIZIONE CONTROLLO OPERAZIONE 30A1	Riferimento PDC: 30A1



Procedura di controllo:
1) Verificare l'integrità del coil assicurandoisi che non ci siano deformazioni al momento del l'asservimento macchina.
2) Se il controllo è positivo scrivere OK nella casella "ESITO RILIEVO".
3) Se il controllo è negativo fermare la macchina ed effettuare la relativa analisi di guasto.
4) Dopo l'intervento effettuare nuovamente il controllo, se positivo specificare le azioni correttive effettuate e firmare nella casella "FIRMA RIPARTENZA".
N.B. NEL CASO IN CUI LE DIME NON FOSSERO DISPONIBILI, PER EVENTUALE VERIFICA IN METROLOGIA, RICHIEDERE IL CONTROLLO ALLA QUALITÀ

DATA	TURNO	MODELLO	TIPOLOGIA RILIEVO	ESITO RILIEVO	FIRMA	AZIONI CORRETTIVE	FIRMA RIPARTENZA

Figure 59Scheda RilievoDati

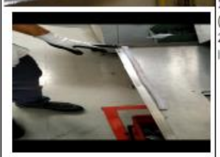
VERIFICHE DA SVOLGERE IN AUTOCONTROLLO DA PARTE DELL'OPERATORE E RELATIVI CRITERI (Per frequenza e strumenti di misura previsti fare riferimento al piano di controllo)					
12	1.Verifica l'integrità del coil assicurandosi che non ci siano deformazioni e difetti estetici al momento dell'assrevimento macchina. 2.Compilazione scheda rilievo dati ad ogni cambio coil.		1.Integrità coil. 2.Compilazione SRD.		1. Eventuali deformazioni del coil causerebbero deformazioni sulle alette e sulle successive lavorazioni. 2.Monitoraggio conformità coils
13	1.Verifica lunghezza dell'aletta utilizzaldo la riga millimetrata. 2.Compilazione scheda rilievo dati aletta front/aletta rear.	 	1.Lunghezza aletta conforme. 2.Compilazione SRD aletta front e aletta rear.	 	1.Perdita confort cliente (scambio termico ridotto) . 2.Monitoraggio conformità lunghezza aletta.

Figure 60: Measurments instruments

In this section, the workers must check after the products is finished if there is any defects in the products so the product of each phase is divided into three cases:

Perfect product: in this case we can continue the procedure to the next phase.

Repairable: products with defects that must have some changes.

Non repairable: products with defects that will be scarps.

We can go back to the section of **the repair of condensers** in order to understand more the how the workers can distinguish between the three cases to take the right decision.

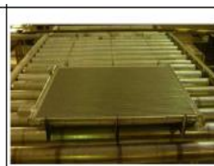
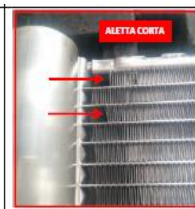
Il conduttore preleva il pacco e lo pone sulla dima, qualora riscontri le seguenti anomalie. 1.Aletta corta 2.Aletta deformata/collassata 3.Aletta fuori passo/passo irregolare In ogni caso di pacco non conforme per aletta corta/collassata/passo irregolare si possono sostituire fino a 3 alette al massimo per pacco, quindi sarà oggettivato con una R di "riparato" prima di depositarlo sul nastro diretto alla brasatura, in caso di più alette non conformi il pacco si deve rottamare. 4.Tubo mal piantato, deformato (non riparabile):rottamato nelle apposite cassette rosse. 5.Pacco danneggiato deve essere immediatamente rottamato nelle apposite cassette rosse. 6.Altri difetti estetici presenti nella scheda limiti di accettabilità (il pacco sarà analizzato da un'operatore specializzato della Qualità)	 	1.Riparabile. 2.Riparabile. 3.Riparabile. 4.Rottamazione immediata 5.Rottamazione immediata 6.Verifica che il pacco assemblato rientri all'interno dei limiti di accettabilità richiesti, dettagliati dalla "Scheda limiti di accettabilità".	   	1.Difetti estetici a cliente, perdita confort. 2.Difetti estetici a cliente, perdita confort. 3.Difetti estetici a cliente, perdita confort. 4.Perdita, non riparabile (non si possono sostituire i tubi) 5.Non riparabile (pacco strutturalmente compromesso) 6. Difetti estetici a cliente, perdita confort.

Figure 61: Examples of defects

In order to see how much the percentage between the repairable and non-repairable in a cue sheet (foglio spunti), where The cue sheet must be filled in with each parcel not compliant so that they can monitor quantities and type of waste, in view of implementation of actions of improvement

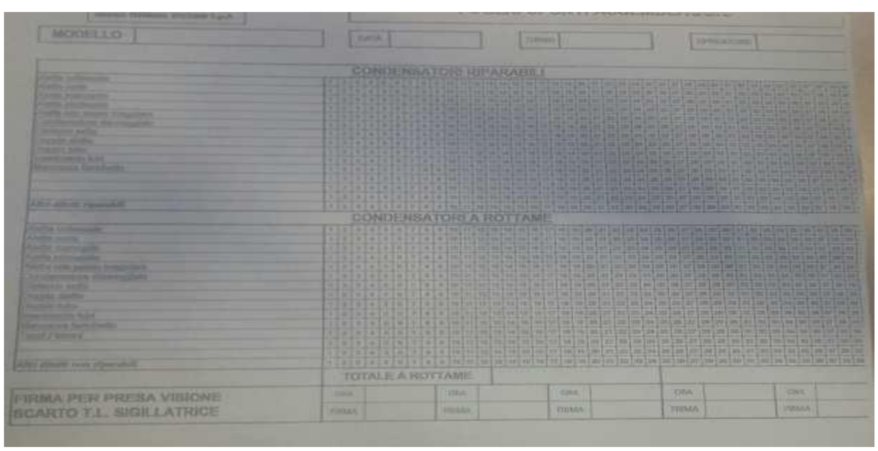


Figure 62: Fogliospunti

5.3 RESULTS

5.3.1 Data collection system

A protocol used by DENSO to collect data on waste. Data collection sheets are simply modules organized in such a way as to make data collection quick and easy, based on subsequent processing. This tool is widely used in the localization and analysis of the causes of dispersion of production processes and for the identification of any defective units. In particular, the data collection sheets are of the "collection for countable data" type, because the data is collected by type of defect in a given period of time (Shift / Day / Month).

In our case, in each production shift the Leaders Team are supplied with cue sheets, each of different types, depending on whether it is the preparation phase of the distributors, condenser assembly, sealing machine loading, sealing machine unloading or analysis / repair area. The cue sheets were constructed by referring to defects found in the past drawn up in a list.

Each turn is divided into four sections, as many as there are workings required to obtain the finished product:

- Assembly phase: in this phase the distributors are assembled, the fins with multiport tubes and the side panels, to form the condenser;

- Sealer line loading phase: in this phase the ΔP control is made, the filters are inserted, the HE testing and the filter body closure (by TIG or with the insertion of the spool);

- Sealing line unloading phase: if the pieces report leaks in the previous phase, these will be selected and manually tested;

- Analysis / repair area: in this phase the pieces are tested at the exit of the sealer, both to identify any leaks and to understand if the piece is repairable or not.

Each phase is characterized by typical defects that can be present in the products, being the typical defects of the phases themselves.

Once the defectiveness is found, the finished product can be:

- repaired: undergoing further processing;

- scrapped.

The balance's needle lies in understanding the seriousness of the defect and how it presents itself. Let's look at an example

The flaw "fall flap" may be present at the sides (therefore in the outermost part of the package), or inside the package. In the first case, the condenser can be repaired by extracting the flap and inserting a new one; in the second case it cannot be repaired because the cost of labor for the repair would be higher than that of the piece itself.

In the first graph we will represent the kind of failure we have in the production of the condensers taking into account all kinds of condensers the company produce. This graph will help us to know where we have to pay attention more during the production in order to reduce the percentage of scraps.

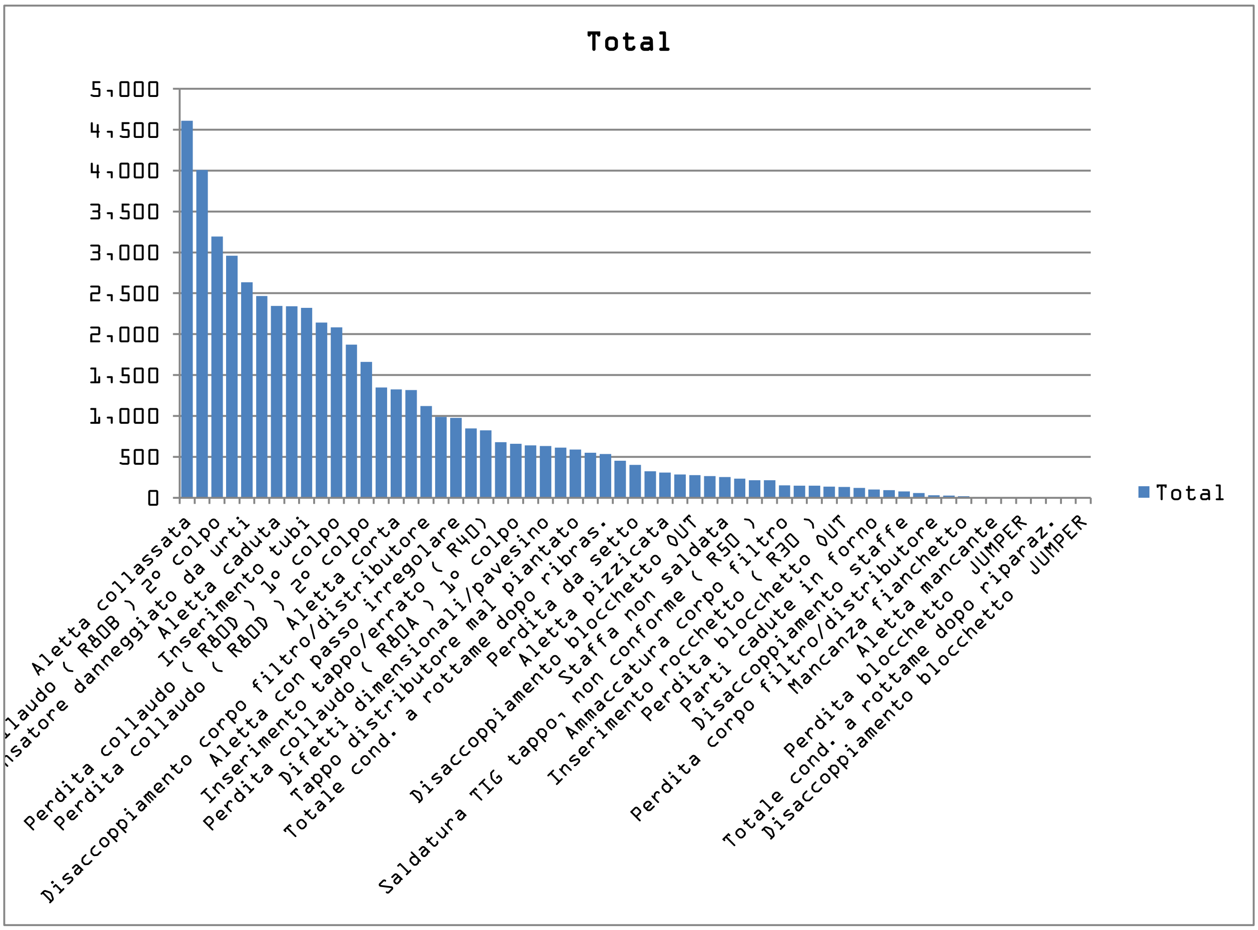


Figure 63: Kind of failures

The principle behind this analysis establishes that among all the possible causes, few of them are responsible for most of the problems encountered.

If we record the problems that occur according to the type or cause that caused them, we can soon find out that most of them (and the consequent cost) are attributable only to one or a few of the many causes identified.

Generally for greater completeness and graphic clarity, the line of the accumulated values is drawn next to the bar chart. In addition, the chart area is divided into three areas:

- Zone A: contains about 20% of the defects which alone make up about 70/80% of the total defectiveness;

- Zone B; it contains about 30% of the defects which make up about 15% of the total defectiveness;

- Zone C; it contains about 50% of the defects which make up about 5% of the total defectiveness;

All that falls within zone A is what you need to work on most to get the fastest possible return on your investment.

Difetti	numerosity	%
Tappo distributore non piantato	0	0,0%
Aletta corta	0	0,0%
Aletta pizzicata	1	1,1%
Inserimento tubi	20	21,1%
Danneggiamenti da urti	41	43,2%
Aletta collassata	19	20,0%
Distributore non piantato	0	0,0%
Aletta con passo fuori tolleranza	0	0,0%
Altri difetti non riparabili	14	14,7%
Totale	95	100,0%

Figure 64: Assembly defects table

Defects	numerosity	%	cost	comulative	
Inserimento tubi	61	91,0%	€ 1.098	91,0%	A
Danneggiamenti da urti	4	6,0%	€ 72	97,0%	B
Altri difetti non riparabili	2	3,0%	€ 36	100,0%	
Tappo distributore non piantato	0	0,0%	€ 0	100,0%	C
Aletta corta	0	0,0%	€ 0	100,0%	
Aletta pizzicata	0	0,0%	€ 0	100,0%	
Aletta collassata	0	0,0%	€ 0	100,0%	
Distributore non piantato	0	0,0%	€ 0	100,0%	
Aletta con passo fuori tolleranza	0	0,0%	€ 0	100,0%	
Totale	67	100,0%	€ 1.206		

Figure 65: Cost distribution

The most important item, for both models, for the assembly phase is:

- Inserting pipes

I will apply this technique to the various stages of the process, focusing on the two models indicated above, to understand which are the problems that have the greatest relevance and that should be resolved as a priority

The second step we can represent the distribution of the quantity of production for each model knowing that these quantities can change depending on the demands from the customers. Moreover we represent the percentage of scarps for all the models which will help us to know which model have the highest number of scraps so we can make the necessary improvements

Model	Product volume	% scraps	N° pieces scrapped	Cost of scraps %	Comulative cost %
A5X	41.000	9,0%	3.690	50,2%	50,2%
Palio	5.350	7,4%	396	8,1%	58,2%
Junior	17.000	3,5%	595	10,8%	69,0%
Global BZ	18.500	3,8%	703	14,3%	83,4%
Atoc B-Suv	7.500	4,0%	300	8,8%	92,2%
Global DS	6.000	3,8%	228	4,4%	96,6%
M3-M4	5.900	3,2%	189	3,4%	100,0%
Totale	**101.250**		**6.101**	**100,0%**	

Figure 66: Percentage of scraps per model

We note that the A5X model alone weighs 50% of the total waste cost.

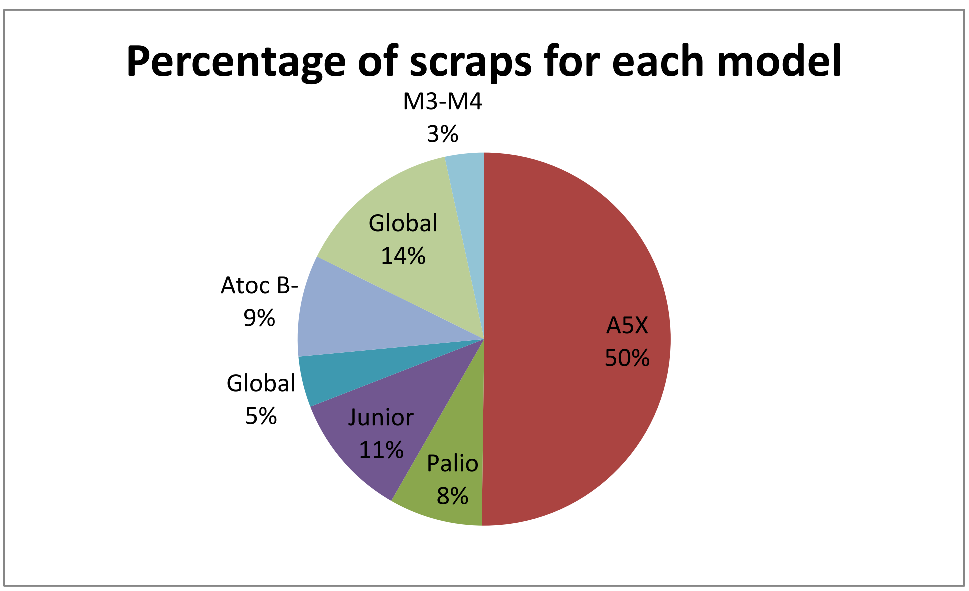


Figure 67: Distribution of scraps per model

For the percentage of difference, the company has set the target around 1-2%, the optimal one, of course, is zero!

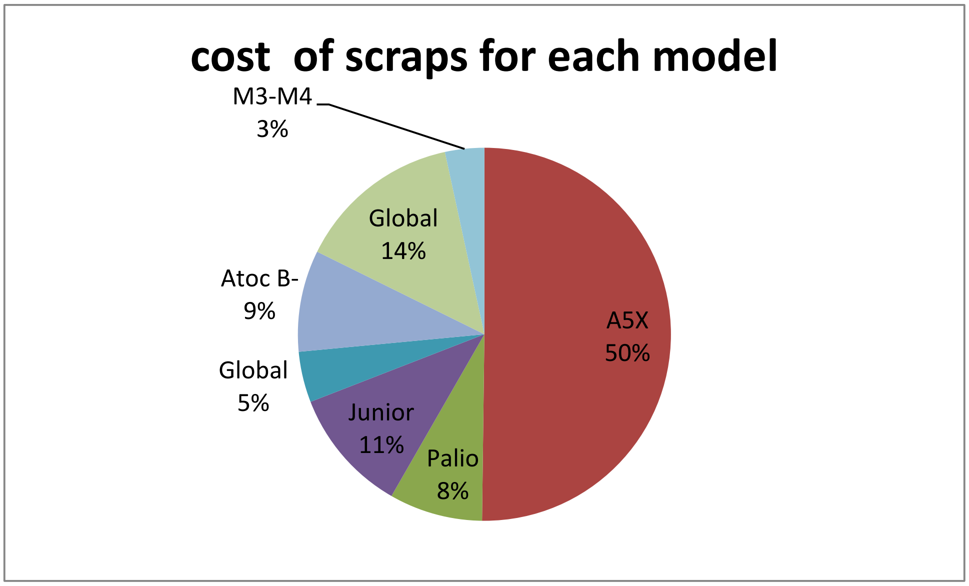


Figure 68: Cost of scraps

By ordering the various models in descending order of the "cost of the waste", the products on which it would be more convenient (from an economic point of view) to intervene will emerge. Let me explain better: as you can see from the table below, there are models that have a high cost of waste, others that have a low one. It doesn't make much sense to invest resources to save a few thousand euros; it is advisable to invest in those models where an improvement in the quality of the process / product leads to high savings (in the order of tens of thousands of euros).

Modello	Costo dello scarto	Costo % Cumulato
A5X	50,2%	50,2%
Global BZ	14,3%	64,5%
Junior	10,8%	75,3%
Atoc B-Suv	8,8%	84,1%
Palio	8,1%	92,2%
Global DS	4,4%	96,6%
M3-M4	3,4%	100,0%

Figure 69: Distribution of scraps

As we discussed in the previous chapters we noticed that at first we will see the percentage of compliance from the first time where at this point the results will refer to the total percentage of scraps

From the percentage of compliant from first time we can notice the improvement that we have especially between june to august where the work instructions started to be more implemented in it's new version and the workers had training taking these instruction as a reference.

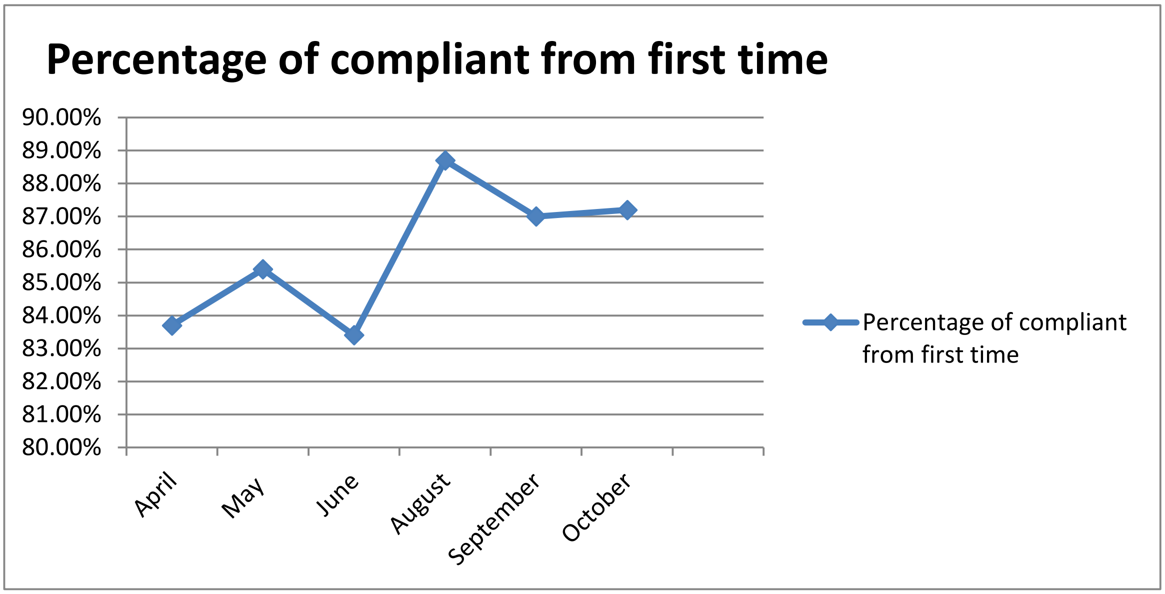


Figure 70: Percentage of compliant from first time

At this stage we can represent the graph of percentage of scraps which represent the scraps at the first stage before taking into account that some of the scraps will go to the rework (percentage of scraps before rework).
In the figure below the we can see how the percentage of scraps is changed between the first four month (april,may,june,july) and the other months in the tight pie (august,september,October) where we have a decrease of approximately four percent.

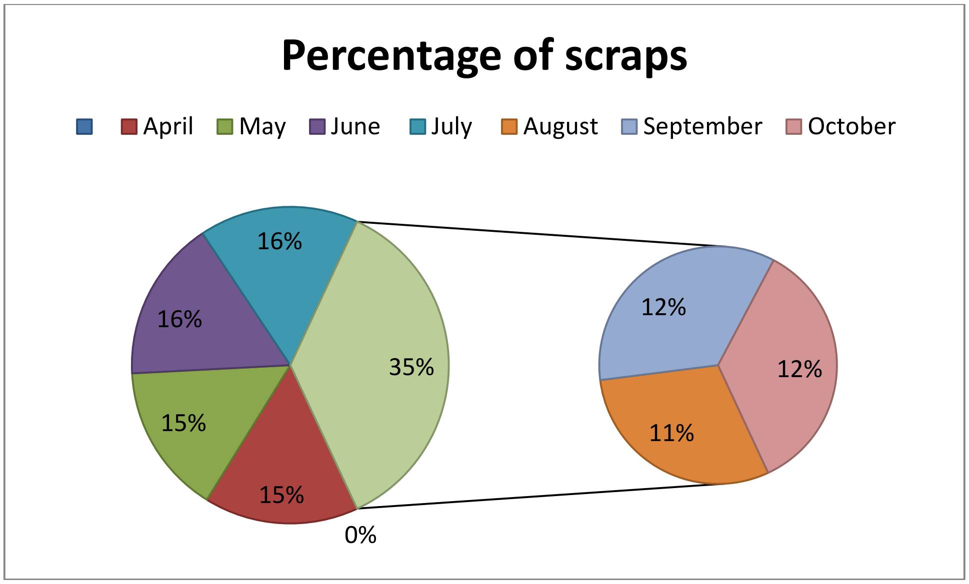


Figure 71: Percentage of scraps before rework

At then we can represent the Percentage of scraps after the rework is done, where this step will reduce half of this percentage

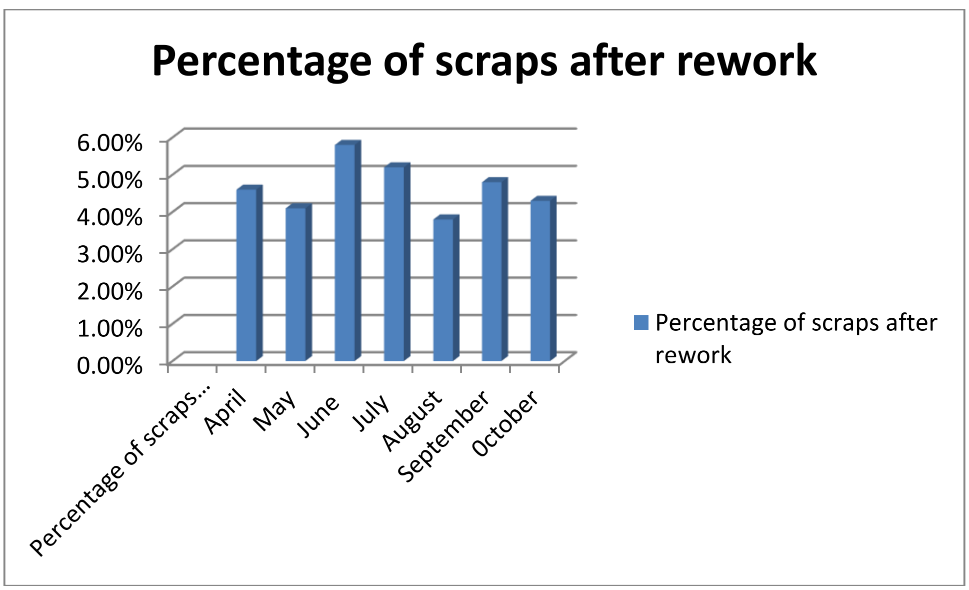


Figure 72: Percentage of scraps after rework

CHAPTER 6

6.1CONCLUSION

The scope of this thesis was to introduce work instruction at the highest level for the production of condensers in order to decrease the variety between all the workers, in order to allow the company to reduce it's internal and external percentage of scraps, so enhance the quality of the product, where quality plays important role in Denso thermal Systems. The work instructions one of the closed chain representing the control plan,fmea,flowchart.Moreover They were approved by plant quality responsible, Human safety engineer and from the production area manager, moreover we discussed them with the customers which gave the the opportunity to have meetings with companies at the higest levels and all this game me push to improve the work in order to have the results needed (Fiat, Ivecco,GeneralMotors,Psa,Renault..).

6.1FUTURE WORK

The work done could provoke other work in the field, at this point we can start talking about digital work instructions with connected worker platform which will give rise to a new generation of work instructions. In digital standardized work instructions we can make sure that al processes are available, consistent and repeatable when using digital solution.

REFERENCES

[1] Franceschini F., Galetto M., Malsano D., Management by Measurement: Designing Key Indicators and Performance Measurements. Springer, Berlin.

[2] Montgomery D.C., Introduction to Statistical Process Control, 5th Ed., J. Wiley, New York, 2005.

[3] Cantamessa M.; Cobos E.; Rafele C. (2007), Il Project management. Un approccio sistemico alla gestione dei progetti,

[4] Frida Deblin and sofie Janson, ,Process for preparing work instructions- A multiple case study at Volvo Group Trucks Operations(04-06-2015)

[5] Ninos saliba, Standardization of a production process-A case study at Husmuttern AB

[6] Vincenzo Fontana,*DENSO THERMAL SYSTEMS S. p. A: Dall'analisi del processo al miglioramento della Qualità,2015*

[7] Malin Olson ,Elin Villeius. Increased usage of standardized work instructionsDevelopment of recommendations for Autoliv Sweden AB ,Göteborg, Sweden, 2011

[8] Nicolo Bellina,Craig Bullock,Patrick Duffy, Study of the impact of standardization-ISUG-2002

[9] *DENSO Global*

http://www.globaldenso.com/en/

[10]

DENSO Thermal Systems S.p.A
http://www.denso-ts.com/

[11] Wikipedia https://www.wikipedia.org/