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Establishing a quality and processes system for portable air conditioner SMAC

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Abstract

A mobile air conditioner, SMAC is being manufactured at Akella systems operating at Sreyas institute of engineering and technology. The trial production was successfully done with 25 numbers in the year 2018-19 successfully. The processes of building a SMAC contained several manufacturing jobs like brazing, fabrication tube bending drilling etc., The quality and processes system should be established and configured with some quality assurance to make the product a perfect and comfortable to use with proper guidance. Several processes carried out are established in a sequential order and the processes time is evaluated. Every process is carried out with inspection and quality check. In the first stage receiving inspection of the BOM items is made for each and incoming material like evaporator, condenser, capillary, compressor etc., In the second stage the inspection is done for the elements like bended tubes copper pipes using the receiver gauges. Here the alignment issues are also resolved if present. The assembling of the portable air conditioner is done with the help of machining process like brazing and defects are checked using soap solution test in o0rder to avoid leakages. In the third stage the tests like online tests psychrometric tests are conducted, the refrigeration cycle performance and customer evaluation are checked. This whole process is done for 5 portable air conditioners. After completing the whole processes, the detailed catalogue is setup and this consists of how to operate the remote and steps of installation.

Index Terms— Manufacturing jobs, quality and processes system, receiver gauges, catalogue.

INTRODUCTION

A culture of quality should be cultivated in an organization which establishes a continuous improvement in the organization. It helps to deliver the products continuously with some standard operating procedure [1,6]. The production processes should be continuously monitored while assembling and setting the product to a well-established manner with all the detailed sketch and layout. The quality management systems are widely applied in construction industry, companies handling big and small projects, food processing industries and several service sectors. A quality management system established by construction system improved the quality of performance of the organization in the sector [2]. The lean production which is based on the Toyota system which is being adapted into other sectors also is profitable and reduces the over burden of the production [3]. The initial step to be taken care of is pointing out the production waste i.e., Overproduction,

Waiting, Transport, Processing, Inventory, Motion, and Defects [4]. For carrying out all these there are some elements to be implemented for lean production processes to happen and the elements are scheduling, employee perceptions, value stream mapping etc. The inspection techniques play a wider role in earning a good quality of the system. Once production has started for any product or a production system is established there must be a conformation that is given by the inspection done. The quality inspection is an important aspect of quality control processes. This also ensures the service and the lifetime of the product [5]. Tasks are performed like testing gauging measuring are the attributes are reasonable for comparing with standard results of the model [6]. The customers get satisfied and show interest in buying a product when it is a well-controlled quality. The product tends to satisfy the desirable characteristics when it is coincided with the features of the standard product. This means that some of the parameters should be satisfying for example, in the portable air conditioner the product that is being manufactured in Akella systems is compared with a standard model called Croma which is another product that used to be sold in the market so frequently [7]. All these are important aspects that need to be taken care of to achieve a better quality. The product tends to fail when the inspection techniques are not conducted properly also there might be a chance that the production process might not be maintained properly. Most of the manual production processes will lead the defects and the flaws should be investigated properly with keen observation and inspection techniques. There are broadly categorized into two and one of them among them is general characteristics [8].

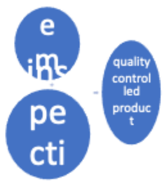


Fig.1: Brief representation of the quality management process and how it is leading to a controlled process

I. SETTING UP THE PROCESSES SYSTEM

It should be generally constrained that while manufacturing a product the system and the environment where all the manufacturing is done with some parameters and standard values. The product that is being manufactured here is a potable air conditioner the reliability and repeatability tests that are followed. DMAIC (define measure analyse improve control) plays a vital role in setting up the processes in a right way for as the steps should be practiced. Defining the production problem is the first and foremost step that should be followed. Problem that came across while setting up the assembly process of portable air conditioner was defects and motion. The process here are being managed by manpower the critical processes like brazing, extra surface removal (grinding) and drilling. It also involves other fabrication processes. Every process is manufactured manually by human skilled labour. In this process the defects are most commonly arising problems and there might not be accuracy of the finished good. Inspection is a compulsory process that should be conducted while manufacturing and after manufacturing.

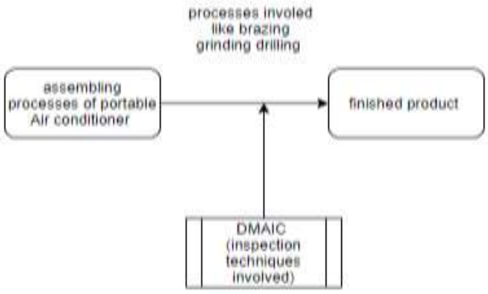


fig .2: detailed view of how DMAIC is helping to define a production problem

following the first step of DMAIC it is to determine the problem. The problem here is defined as defects caused while manufacturing. The defects might be raised while brazing like blow holes surface leaks and over melting of metal. Before doing processes inspection the incoming material should be done and compared with a standard element or model. The coming materials like condenser, evaporator, compressor, frame, outer body, blowers, motors are checked out for flaws and defects.

A. INSPECTION OF THE INCOMMING MATERIAL

a. Compressor

Compressor is a device in which work is done on the system thereby increasing the pressure and temperature of the refrigerant. It leads the refrigerant to the superheated state from the saturated state. Compressors used in air conditioning and refrigeration are hermetic[9].The "common, start, run" readings give the decision whether the compressor is going to run or not. The internal load acts in the common terminal which gives the indication whether the compressor is getting heated. The resistance between common and run will read to infinity and prevents the compressor form running if the system is getting tripped. In the above table inspection has been done to the compressors which has R22 and R134 a working fluid. Three categories of errors are formed they are 0.1, 0.2, 0.6. The compressors showing 0.6 as the as the error were tripped off.

B. STATIC BALANCING OF THE BLOWER

The blower which is used to manage heat transfer processes should rotate without any wobbling and misalignment. The wobbling effect caused to the blower may displace the blower from the shaft. Sometimes the blower can even get separated from the shaft which is dangerous and can be accidental. To avoid phenomena like that a tight closure seal is set up. The seal looks like a cap that is attached to the threads joined. A brief tabular format is made listing the specifications of the perfect standard model

specifications of the blower	
material:	Fibre
motor attachment type	bush fitting
speed of the motor that blower can be rotated:	1500RPM

Table1: specification of the blower

fig.3: attaching a bush for perfect alignment of the motor shaft

Fig.4: covering the blower front portion with a cap so that the blower will not move axially

S.NO	Compressor Model	Refrigerant Used	CR reading Ω	CS reading Ω	SR reading Ω	Error= SR-(CS+CR) Ω
1	PH150G1C-4DZH	R22	4.3	5.3	9.0	0.6
2	PH210M2A-4FTL1	R22	2.4	3.3	5.6	0.1
3	PH210M2A-4FTL1	R22	2.8	2.9	5.6	0.1
4	PJ250M2C-4FT	R134A	1.8	2.5	4.1	0.2
5	BSA645CV-RIEN	R134A	3.1	4.1	7.1	0.1
6	PH210M2C-4FT2	R22	3.3	3.2	6.3	0.2
7	PH210M2C-4FT2	R22	2.4	3.8	5.6	0.6

The specifications to be defined for the condenser	
fin and tube condenser	3row
Dimensions:	14” * 14” (l*b)
Diagonal length:	20”
Tube diameter:	1.25cm outer dia.
Fin spacing:	1.2mm
Horizontal distance between two tubes:	8mm
Vertical distance between two tubes:	10mm
Thickness of the support:	2.04cm
Thickness of the condenser:	6.5cm
Total number of condensers inspected:	5

Table 3

The specifications to be defined for the condenser	
fin and tube condenser	2row
Dimensions:	12” * 12” (l*b)
Diagonal length:	17”
Tube diameter:	1.25cm outer dia.
Fin spacing:	1.2mm
Horizontal distance between two tubes:	8mm
Vertical distance between two tubes:	10mm
Thickness of the support:	2.0cm
Thickness of the condenser:	4.0cm
Total number of condensers inspected:	5

Table 4

B. INSPECTION OF HEAT EXCHANGER

The nitrogen present inside the tubes has a constant pressure, when there is a leakage the pressure might get reduced due to punctures on the tubes. The pressure of nitrogen might vary when it is removed from the tubes of condenser which are sealed. Punctures on the tubes can be visualized by a human naked eye, and variation in the sound of the released nitrogen can be sensed due to leaks in the tube. The nitrogen present inside the tubes has a constant pressure, when there is a leakage the pressure might get reduced due to punctures on the tubes. The pressure of nitrogen might vary when it is removed from the tubes of condenser which are sealed. Punctures on the tubes can be visualized by a human naked eye, and variation in the sound of the released nitrogen can be sensed due to leaks in the tube.

fig.5: Releasing nitrogen gas from the tubes for the inspection

C. *SURFACE INSPECTION OF CONDENSER*

The condenser should be aligned on the frame and attached to the blower and the enclosure of the condenser should be perfectly aligning with the blower casing so that there is no exchange of air or loss of the air to the atmosphere while the heat exchanging process takes place. The spirit level is used to inspect any surface irregularities and other alignment issues.

fig.6: spirit level place on the fin & tube heat exchanger

After checking the flaw and alignment issues the standard sizes and dimension are noted don for further inspection.

The dimension and specification of the heat exchangers are mentioned in the tabular form above.

There were no rejections found in the inspected 10 heat exchangers and all the inspected models are thereby approved for assembly.

III. Inspection of the fixture's attachments

A. INSPECTING THE BENDED TUBES

The tubes are bended and the bending's should be accurately bent and properly set up in order to connect the tubes with condenser, compressor, evaporator, and expansion valve. To find out if the tubes are bended or not gauges must be employed. The simple way to approach these gauges are making them with paper pulp and binders and they can be called as low-cost receiver gauges.
The process used to prepare the receiver gauge is listed below

- Take waste papers or newspapers or any other papers, make those paper into small pieces with different methods like paper grinding etc., take a bucket, pour water into it and soak the paper in that water for two days,
- take a box of required dimensions and with only one side open, pour the water and fevicol (adessive) into the cup with 80 percent of fevicol and 20 percent of water and mix that mixture in that cup.
- Place the standard copper tube into the box, now fill the box with the paper pulp mixture and ram the pulp mixture so that the pulp fits accurately in the box without any air gaps.
- After filling the box with the paper pulp, apply fevicol on the outer surface of the paper pulp and let it dry for two to three days and remove the paper pulp from the box.

Fig.9: Gauge ready for drying

B. BRAZING AND SOAP LEAK TEST

The brazing operation is performed in the joints of the elements where copper tubes are connected to the other elements of the refrigeration circuit. There might be leakage of refrigerant at the joints the leakage should be checked with the soap bubble test after charging the refrigerant.

fig.10: brazing operation performed

C. CIRCUIT TESTING

The circuit testing is a part of online inspection where the whole refrigeration circuit is tested at all the points and consistency of the system is found out. The circuit is tested by setting up thermocouples at the points given in the below table and the temperatures are taken by setting up a constant dry bulb temperature and wet bulb temperature. The time until the compressor gets tripped off is noted.

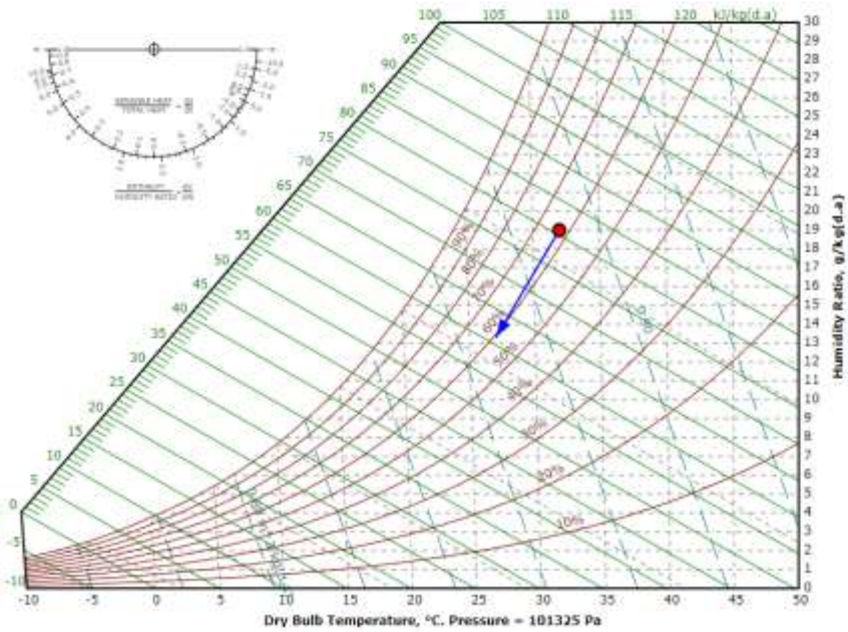
The room where the unit of portable air conditioner was being placed maintained a constant temperature of 39 ^{0}C Dry bulb temperature and 37.6 wet bulb temperature. The system was able to perform consistently up to 40 min and the compressor tripped off. This means that the compressor can constantly do work on the system up to 40 minutes when the heat load is maintained at 39^{0}C. The heat transfer can take place and cooling effect be produced and served in the room when a constant temperature is maintained as mentioned above. The thermal load bearing capacity was decided by referring the observations in Table.5.

product SMAC125					
Test duration: 40 min			condenser type: 14" *14"*3 row		
capillary: 0.090" *51"* 1unit			evaporator coil: 12"*12"*2 row		
S.no	environment	10min	20min	30 min	40min
1	RETURN GAS	19	20	17	16
2	DISCHARGE GAS	101	114	117	123
3	LIQUID LINE	65	68	68	68
4	SHELL TOP	103	119	123	125
5	SHELL MIDDLE	104	119	125	128
6	EVAPORATOR IN	11	12	12	11
7	EVAPORATOR OUT	17	17	18	12
9	CONDENSER MIDDLE	63	67	67	67
10	AIR IN	32	34	31	31
11	AIR OUT	18	19	18	18
power consumption parameters					
1	current	7.65	8.35	8.4	8.43
2	voltage	220	220	220	220
3	power	1683	1837	1848	1854.6

Table.5 temperature readings under constant load and DBT and WBT

IV. PSYCHROMETRIC ESTIMATIONS

The psychrometric estimation is done for the portable air conditioner to find out the effect of cooling in a room as the processes is cooling and dehumidification. The psychrometric readings were taken out from a graph through an online psychrometric property plotting software [10]. The result and other parameters are shown below in graph. The input parameters are given initial conditions as 30^0C DBT and 27^0C WBT and the final condition for the portable AC were 26^0C DBT and 22^0C WBT which reached after the processes. The entire unit was tested in the offline mode i.e., in an ambient room and found how temperature was decreasing. The enthalpy, humidity, humidity ratios were found out from this graph fig.12. The above-mentioned parameter values are given in fig.11 which are extracted from the software


kJ/kg(d.a)
Humidity Ratio, g/kg(d.a)
Dry Bulb Temperature, °C. Pressure = 101325 Pa

State changes from point A to B		
Dry air flow:	1000	kg/h
Delt.H/Delt.d	3.464	kJ/g
Heating load	0.000	kW
Cooling load	5.472	kW
Humidifying	-1.580	g/s
Sensible heat	-1.424	kW
Latent heat	-4.048	kW
Mixed air from state A and B		
Point A percent:	15	%
T.Dry.Bulb	27.750	°C
T.Wet.Bulb	21.758	°C
T.Dew.Point	19.235	°C
Rel.Humidity	59.827	%
Spec.Humidity	14.054	g/kg(d.a)
Enthalpy	63.764	kJ/kg(d.a)

Fig.11 : finding parame

Fig.12: Psychrometric plotting of the parameters

V.TEMPERATURE CHANGE WITH RESPECT TO TIME AND SET TEMPERATURE

The temperature of the system is set to 16 degrees but the room is gradually cooling from 30 degrees and it is recorded that the temperature is decreasing very slowly the temperature readings are taken and noted down and graphically the values are plotted the temperature was recorded from a distance of 1.7 meters.

distance 1.7m model 1		
time	room ambient temperature	Set temp.
11:46	30	16
11:51	30	16
11:56	30	16
12:02	29	16
12:07	29	16
12:12	28	16
12:18	27	16
12:22	26	16
12:28	26	16
12:34	26	16
12:40	26	16

Table.6 The readings were taken from the distance of 1.7 meters of the unit and temperature effect was recorded

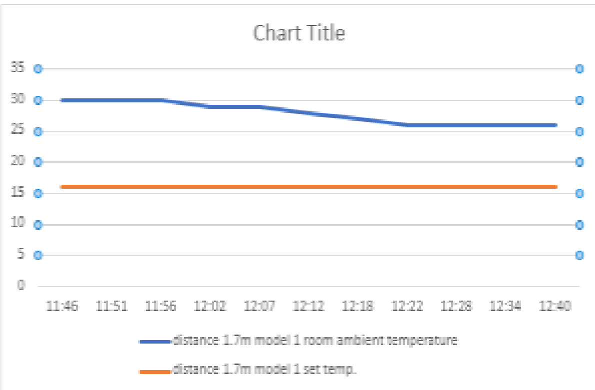


fig.13: graph between time and set temperature, and ambient

VI. CONCLUSION

- The final product is ready after getting involved in several inspection techniques
- The DMAIC rule was helpful in developing the production problem's solution
- After testing the refrigeration circuit, the outcome was found that it could retain in the circuit 40 min at a constant DBT and WBT. Through this the maximum heat that can be sustained is found out through psychrometric chart.
- Ambient temperature was changing with a difference of 4^0C from the initial value when the set temperature is 16^0C
- By conducting such type of inspection techniques, the defects were resolved.

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A convenient, precise and customizable psychrometric chart & calculator tool for HVAC engineers. Support IP and SI units