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Research Article

Design of Fin Insertion Station in Radiator Assembly Line

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Abstract

Radiators of different shapes and sizes require different radiator core builder machines to suit their configurations and dimensions. We present a design of such a machine that will be used for forming the tube-fin matrix as a part of assembly of radiator cores. It improves upon the existing type of machine by using a single structure for the entire assembly of radiator core. Also, it can be used to assemble cores of different sizes by incorporating perpendicular linear motion rails which can change the distance between the tube holders. This makes the machine very flexible and also saves time and floor space.

Keywords: *Radiator assembly,core builder,semi-automatic,apparatus, pneumaticcylinders, tube-fin matrix.*

1. Introduction

Radiators must be highly durable and efficient to satisfy the cooling needs of high performance engines used nowadays. There has been a lot of innovation in radiators over the past technology and today they are more sturdy and light-weight than their old day counterparts. There is a lot of variety if shapes, sizes and configurations of radiator are considered but there are some universal aspects as well which remain same in every radiator. Liketo increase the heat transfer rate fins are provided which increase the heat transfer area and thus rate of heat transfer. All radiators are made up of some basic components like tubes, fins, side plates and heater plates.

Fig.1.Radiator

Similar to other manufacturing systems, the method of assembly of radiators has been refined over years. Radiator core assembly machines have become highly precise and consistent leading to the production of a generation of dependable, long-lasting radiators. They are usually fabricated with the use of automation equipment that includes core builder machines. Once the water tubes, cooling fins and other components have been manufactured as per the specifications of given model of radiator, they are often placed manually on a work holding fixture where they are then compressed and tightly banded together. Therefore, radiator construction requires a proper coordination between the efforts of workers and the systematic processing capabilities of automated manufacturing equipment.

Most of the core building machines include an elongated table on which the cores are supported and transferred to the various assembly portions of the machine. The apparatus used earlier consisted of two different stations, one for forming tube-matrix and the other for inserting fins and assembly of the radiator core. Also, the prior apparatus and methods are not very flexible in that they do not allow for the easy manipulation of the machine to manufacture radiator cores of various sizes. (US Patent No. 6067704, 2000)

We designed an apparatus which uses a single station for the entire assembly. This provides a continuous path, eliminating the need to move the radiator core from one station to the other, which saves time and leads to reduction in required floor space. Also, this apparatus provides increased flexibility as it can accommodate e various sized radiator cores. This is achieved with the help of perpendicular linear motion rails which can change the distance between the tube holders.

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Radiator assembly station

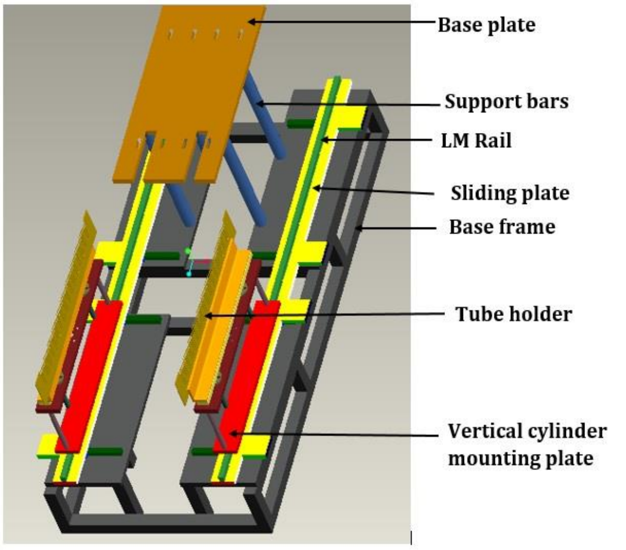

Fig.2.3D model of the machine

Table 1. Components

Major	Minor
Cylinders	Reaction pins
Tube holder	Support bars
Core support clamping block	Pressure regulating valves
Base frame	
Base plate	
LM rail	

2.1 Mechanisms involved

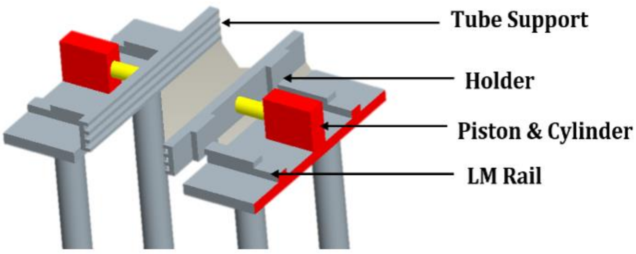

Fig.3. Mechanism to maintain the gap between the Tubes

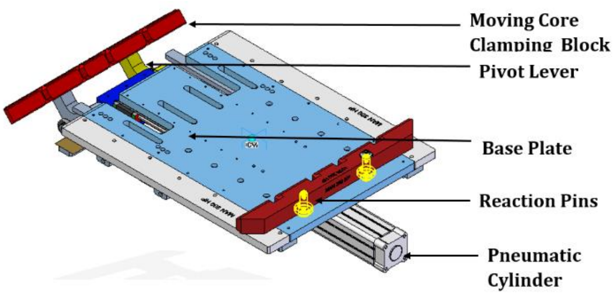

Fig.4. Radiator core compression mechanism

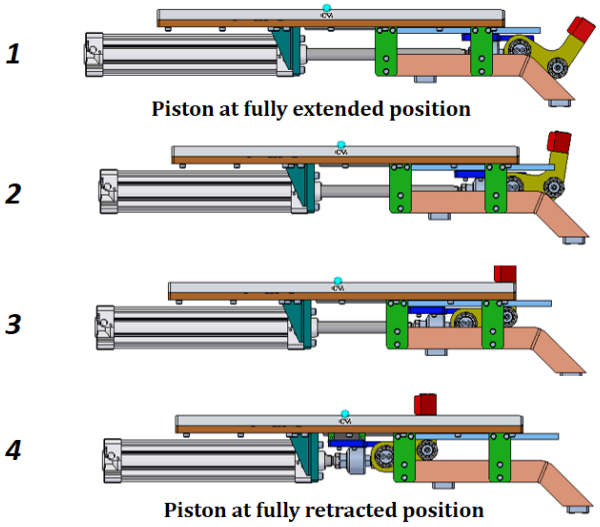

Fig.5. Different positions of the piston used for core compression

2.2 Operations

The tube-matrix is formed on the first half portion of the station. Evenly spaced comb-like structure is used for achieving the required gap in radiator tubes. Identical tube holders are provided on both sides of first station. Two drawers are provided on each side for creating three tube layers. Gap between tube holders is adjustable to accommodate different length of tubes.(US Patent No. 4611375 A, 1986).

The operator places side core support on the fixed block. Then the tube-matrix is moved to the base plate through guideways along with the tube holder using a hydraulic cylinder at the bottom of the apparatus. The tube holder which is mounted on pneumatic cylinders is moved downwards and back to the first portion. Fins are inserted manually between adjacent pair of tubes and also between each side core support and the adjacent endmost tube in the array of tubes. The spacing between the tubes is kept more than required so as to easily insert the fins in between adjacent tubes without any damage. After the fins and tubes have been loosely arranged in side-by-side relationship, the moving block with the core support is moved using pneumatic cylinder to compress the loose tube-fin assembly to reduce the spacing between adjacent tubes to a point where the fins are firmly clamped between the tubes and core support assemblies. This compressing action is also employed to line up the individual tubes with the tube receiving openings in the header plates.(US Patent No. 4611375 A, 1986).

The motion of the tube holders from the first portion to the base plate is facilitated by the linear motion rails present along the length of the machine. The transverse linear motion rails facilitate the lateral motion of the tube holders in both directions, thus allowing the assembly of different sized radiator cores.

2.3 Hydraulic synchronizing circuit

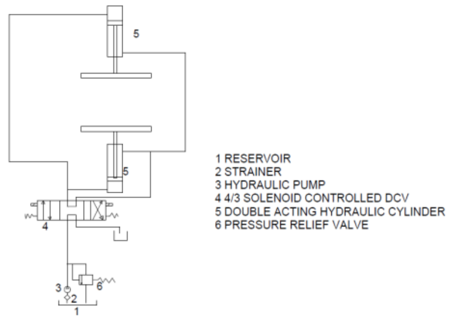

Fig.6. Hydraulic circuit

Fig.6 shows a two-cylinder hydraulic synchronizing circuit used to actuate both cylinders simultaneously with the same speed. Its purpose is to apply pressure on the radiator core from both sides so as to hold the tubes and fins in their position while compressing the radiator core.

Pump is used to pressurize the fluid from the reservoir before passing it to the direction control valve. The fluid is passed through strainer to remove any impurities if present. The fluid coming out from the rod side of cylinders goes to the reservoir. For retraction stroke, position 3 of direction control valve is engaged. Hence it flows to the rod side of both the cylinders and presses the piston with equal pressure thus causes the movement of both pistons with same velocity. Fluid coming out from piston side of both cylinders flows to the reservoir. Direction control valve is normally kept in position 2 thus keeping the system in idle during normal working. Pressure relief valve is also provided which actuates if the pressure exceeds the limit and bypasses the fluid to the reservoir.

2.4 Pneumatic circuit

Fig.7 shows a pneumatic circuit used for compression of radiator core on the base plate. The pneumatic cylinder is situated at the bottom of the base plate. Initially power pack supplies desired power to start the operation. Once air is received it is passed through filter, regulator, lubricator. This improves the quality of air by removing impurities and lubricating

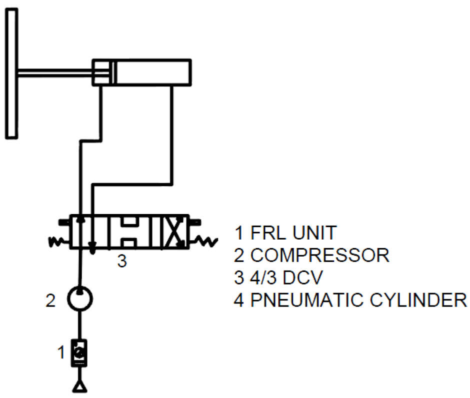

Fig.7. Pneumatic circuit

it. Now air is passed through 4/3 direction control valve. Initially piston is in extended position. Position 1 of direction control valve is engaged to start retraction stroke of piston. During this retraction stroke it compresses the radiator with the help of core support moving block. Stroke of piston is such that radiator is compressed up to desired length. During this retraction stroke air on bore side of cylinder is vented to atmosphere.

2.5 Selection of cylinders

2.5.1 Vertical pneumatic cylinder for vertical motion of tube holder

Weight, $W = m \times g$

Frictional force, $Ff = \mu \times m \times g$

Force required for acceleration of tube holder, $Fa = m \times a_t$

Total vertical force required, $F = W + Ff + Fa$

Force required considering factor of safety, $\mathrm{Fr} = \mathrm{F} \times FOS$

Diameter required, $d = \sqrt{\frac{Fr}{P} \times \frac{4}{\pi}}$

2.5.2 Horizontal pneumatic cylinder for compression of radiator core

Frictional force, $Ff = \mu \times m \times g$

Force required for acceleration of moving block, $Fa = m \times a_b$

Force due to resistance provided by fins (acting as spring), $Fs = k \times x$

Total force required, $F = Ff + Fa + Fs$

Force required considering factor of safety, $\mathrm{Fr} = \mathrm{F} \times FOS$

Diameter required, $d = \sqrt{\frac{Fr}{P} \times \frac{4}{\pi}}$

Future scope

The presented method is a semi-automated one. It involves manual insertion of tubes in the tube holder and the fins between the tubes. Further mechanisms can be developed for the insertion of tubes and fins to increase the productivity and reduce dependence on labour.

Nomenclature

m Mass of tube holder and tubes
g Acceleration due to gravity
μ Coefficient of friction
a_t Acceleration of tube holder
FOS Factor of safety
P Applied pressure
a_b Acceleration of moving block
k Stiffness of fins
x Distance for which fins provide resistance during compression

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