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Research Article

Design and Development of Tube Matrix Formation Station: A Study

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Abstract

Aim of this project is to provide a turnkey solution to achieve the matrix of radiator i.e. radiator core. Radiator core consists of uniformly spaced tubes and fins placed within the spaces between adjacent tubes. Conventional methods turn out to be unsuitable for this function. This paper is concerned about assembly machine for radiator core for low batch production. As demand for the radiators is low. Therefore, automation cannot be a choice because of the price constraints. Eventually, best choice is to have manually operated machine. The machine consists of hydraulic actuators for a pressing operation, brackets for cylinder and core support. For complete design of assembly machine, design of these crucial components is need to be done as explained further in the paper

Keywords: *Radiator matrix, radiator core, manual operation, special purpose machine, hydraulic circuit*

1. Introduction

Radiator is a very essential component of automotive. It is required for cooling the oil used for cooling engine parts. There is ever increasing demand for radiators in automotive industry so it becomes essential to develop a special purpose machine for the manufacturing of radiators. Considering the demand of the product in the market the type of machine to be manufactured is decided. A fully automated machine is used for mass production and production of components with continuous demand. Semi-automatic machines are used for medium production rate. While for manufacturing a component with low demand, the best choice is to opt for manually operated machines.
This paper is about assembly machine of radiator core for low batch production. As demand for the radiators is low. Therefore, automation cannot be a choice because of the price constraints. So best choice in this case is manually operated machine. In most of the tube matrix formation machines, there is provision that the operator spreads the tubes and the tubes get settled in the slots provided in fixture. Then the operatorinserts finin the spaces between tubes. Radiators which are to be manufactured on the following assembly machine are relatively larger i.e., 1420.6±1 x 22±0.05 x 1.9289±0.01 mm and 1400±1 x 675.8±2 x 74 mm. If the same mechanism as described above is used, it becomes difficult for the operator to insert the tubes in one pass and complete the task.

Therefore, there was a need to change the mechanism and hence mechanism with provision for insertion of tubes vertically is used which has C-section (for one stack of tube and fin) guideways. These guideways are brought closer and plates and fins are inserted. Therefore, this is a special purpose machine for manufacturing large sized radiators for generators. The methodology for this project is determined with the help of guidelines in machine design handbooks.

The following procedure is followed for this project.

A] Studying the product to be manufactured on the station:

I. Dimensions of radiator:
   a. Length of tubes
   b. Spacing between rows of tubes
   c. Spacing between tubes
   d. Height of fins
II. Structure of product
   a. Structure & components
   b. Number of tubes in the matrix

B] Determination of process flow for performing the tube matrix formation:

   a. Consideration of required production rate
   b. Conceptual designs

C] Finalizing the mechanism

D] Computer-aided design

2. Literature Survey

Mr. John J. Zapawa of Progressive Tools and Industries Co., Southfield Mich in his patent [Patent No: 4611375]

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for Assembling Radiator Cores apparatus. This apparatus is used for radiator core subassembly including number of individual tubes (disposed uniformly spaced), fins inserted between adjacent tubes. It consists of a pair of finger assemblies operating at opposite sides of a support table. The finger assemblies each include a series of vertically disposed fingers interlinking to each other in a horizontally extensible chain. When the chains are extended, tubes are inserted between the fingers which are spaced such that there is adequate room for the fins to be accommodated between the tubes. Subsequent compression of the finger chains moves the tubes and fins into their final assembled relationship to each other.

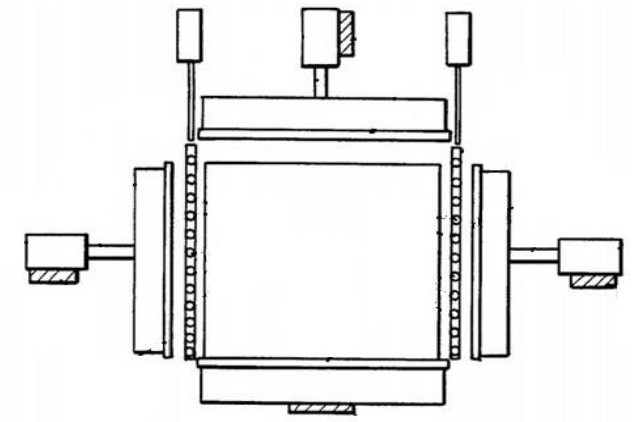

Fig. 1 Radiator Cores Assembling Apparatus

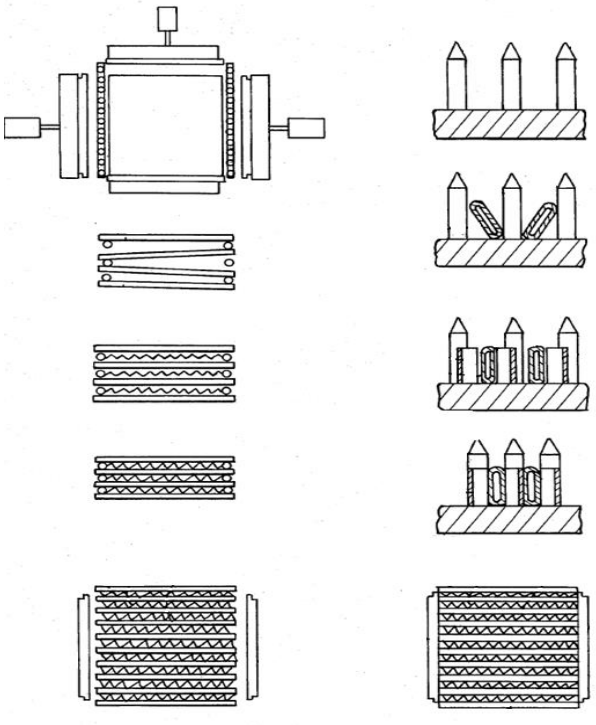

Fig 2. Subsequent Steps in Assembly Process

Richard E. Carlson, Jamestown, N.Y., assignor to Black stone Corporation, a corporation of New York filed a patent [Patent No: 3431620] for an Apparatus for Assembly of Tube and Center Radiator Cores[1] which comprised a means for successively delivering a formed length of separator, guide means receiving the separator and resiliently holding the same, a pusher means advancing each separator into the guide means, a magazine means delivering at least two side-by-side tubes onto each length of separator and means in the guide means maintaining said tubes spaced from each other on the separator.

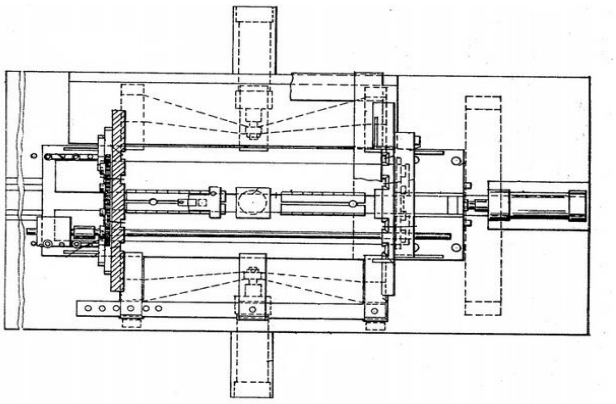

Fig. 3 Apparatus for Assembly of Tube and Center Radiator Cores

These machines used for assembly of tubes and fins for the assembly of radiator core are very old and the mechanisms were implemented in complicated manner. As these mechanisms have some disadvantages, there advantages and basic idea of mechanism, construction cannot be neglected. Finding out the best and reliable mechanism and eliminating the difficulties and disadvantages of previous mechanisms, it is necessary to study the detail manufacturing process of radiator core, i.e. pre-assembly and post-assembly defects.

Fig. 4 Assembly Jig

3. Comparison with Earlier Methods

Inthe Mr. John J. Zapawa'smechanism, the operator had to insert the tubes first in the grooves provided in the

mechanism. Then the job was to insert the fins in the space between the two tubes. Space between the tubes is kept slightly larger in order to have ease of insertion of fins between two adjacent tubes. Now in the proposed mechanism the operator has to insert the tubes and fins alternately in order to form the stack of tubes and fins. This improvisation has been done because of the relatively larger size of radiator. Due to larger size of the radiator (1420.6±1 x 22±0.05 x 1.9289±0.01 mm), it was difficult for operator to spread tubes and fins between them over a large length. So, we opted mechanism in which tubes and fins are inserted vertically.

The mechanism provided by Richard E. Carlsonwas automated but assembly machine in the following paper is about low batch production of radiator cores. As the daily requirement for manufacturing radiator is only 5 to 6. So, idea of automation was ruled out. Thus the mechanism that is implemented for tube matrix assembly station is cost effective for low production rate.

4. Proposed Design

Considering the requirements of client, a conceptual design for the mechanism for the tube matrix formation station is proposed. In this paper, aim to design guideways and other supporting parts for retaining the matrix of tubes and along with that a system for pressing alternate layers of tubes and fins to obtain required dimensions. Operations performed by operator on the station for Assembly of radiator core:

1. Maneuvering tube guides inward by rotating the screw with the help of handle attached it at the end.

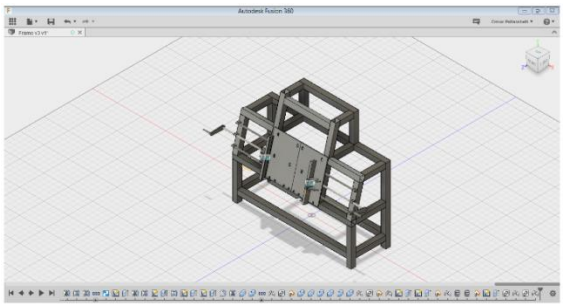

Fig. 5 Proposed Design

2. Insertion of bottom support plate at the bottom end of guide for tubes.
3. Putting aluminium tubes and fins into the guide alternatively to form the matrix. Insertion of top support plate at the top of matrix.
4. Hydraulic pressing of the matrix by extension stroke of hydraulic actuator in order to obtain required arrangement.
5. Putting C clamp on the matrix to hold the same.
6. Retraction stroke of hydraulic actuator.
7. Maneuvering tube guides outward by rotating the screw with the help of handle attached it at the end in order to release the matrix.
8. Pulling out the matrix and sending it to next station with the help of crane.
9. Pulling out the matrix and sending it to next station with the help of crane.

4.1 Components

A] Standard Component:
   a. Hydraulic actuator
   b. Bearings- 6205Z
   c. LM rail- GH25
   d. Fasteners-Allen bolts

B] Custom Designed Components:
   a. Frame
   b. Brackets
   c. Support Plates
   d. Bottom Support
   e. Lead screw and Nut
   f. Guideways

4.2 Design of Components of Tube Matrix Formation Station

This proposed design of special purpose machine consists of components as follows:

1. Supporting plate
2. Guideways
3. Brackets
   i. Cylinder holding brackets
   ii. Bottom support bracket
4. Ball Bearing
5. LM rail

– Principles of selection
   i. Load carrying capacity
   ii. Cross section and available space
   iii. Linear running accuracy
   iv. Speed and acceleration
   v. Stiffness of linear rolling guides

4.3 Salient Features of Tube Matrix Formation Station:

– The station is used for manufacturing of radiator core for two variants (1420.6±1 x 22±0.05 x 1.9289±0.01 mm and 1400±1 x 675.8±2 x 74 mm.)
– Suitable for low batch production
– Effective production cost.
– Ergonomically designed for easy and precise manual operation.
– Simple mechanism

4.4 Applications

– For manufacturing of Radiator for Generator Cooling System.
– In the manufacturing of Intercoolers.

Discussion

In this paper, the mechanism and design for SPM is finalized. The ergonomically designed assembly machine consists of lead screws driven manually by handles to move guideways on the L-M rails. In this project components like lead screws, guideways, brackets, supporting frame structures are designed from scratch while components like L-M rails, bearings and elements in hydraulic circuit are selected from standard variants available in market. The theory regarding it has been finalized and the design will be confirmed as the final part of this procedure. A visit to the "Tata Toyo Radiator Ltd" campus has been planned to observe the testing of the machine and draw the final conclusions regarding the performance of the machine.

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