



MICHIGAN CUSTOM MACHINES, INC.

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Product Highlight:
INJECTOR ASSEMBLY & TEST

This particular machine was designed to assemble and test a complete diesel fuel injector all in a self-contained package with a small footprint. A single operator loads pallets with the individual components that make up the injector. As the pallet passes through the machine, the injector is incrementally assembled and tested for different characteristics and marked for identification. The design is flexible to accommodate future product design and increased product throughput. The entire package is also easy to relocate, requiring little installation and tear down.



Background

A typical “pump and lines” diesel injector is fed by a high-pressure unit pump that dispenses a specific volume of fluid depending on throttle position. The injector acts as a poppet valve that opens at a specific pressure and then dispenses fuel through a number of precisely machined orifices. At the end of the injection, the valve snaps shut just prior to combustion. Engine emissions, fuel economy and performance are tied very closely to the performance of the fuel system feeding it. Our machine measures the flow rate through the nozzle tip to verify that the injector delivery will be correct, the VOP or “valve opening pressure” at which the injector snaps open and two leaks tests: guide leak and seat leak. These particular injectors rely on a predetermined spring load that dictates the valve opening pressure. The spring is preloaded by a shim that is selected appropriately to accommodate variations in stack height tolerance. The whole system is captivated by a cap that also varies in dimension. Our machine chooses the appropriate shims by operating the injector in a semi assembled state, assembles it and verifies the operation of the completed assembly.

Machine Features:

- Accommodates several injector products with minimal changeover.
- Pallets are tracked with RF tags meaning that pallet order is unimportant and can be random.
- Each test station pulls out on slides so that the hydraulics can be easily serviced.
- Machine logs all test results to local hard drive.
- Machine vision verifies stamping on body against currently selected part parameters.
- Designed for one man operation.
- Functional test station performs mass flow, VOP, guide leak and tip leak tests selectively and in any order.
- Assembly station uses a multi axis robot to select shims from forty different magazines. These magazines can be loaded in any position, as the machine will learn what shim thickness has been installed. This robot also installs the cap in a nut runner.
- Assembly station uses an encoder to measure every shim prior to installation to guarantee that the correct shim was installed.
- Sensors detect the presence of an o-ring that should have been installed on the part.
- Each station can be manually operated for debugging.
- Pallets can be routed to one station only, all of them or any combination. This is useful for running masters or marking parts.
- One hydraulic power unit provides temperature conditioned calibration fluid to all of the stations.
- All filters have two stage differential pressure switches to provide an early warning of filter failure.
- Automatic plant fill circuit refills the calibration fluid tank from a plant feed, when the tank becomes low.
- Spare station slots can accommodate redundant stations for faster throughput or different stations so that products can be intermixed in the future.

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Economical

Using one of our test and assembly systems, not only reduces the number of people involved to assemble your product but reduces the amount of floor space required by a normal assembly cell. There is also no requirement for your IS department to link it all together as the machine already manages the parameters and the collection of all of the result data. Finally, the cost for one of these machines is a lot less than you think.

Sequence Summary

The operator is required to load the injector components on to a pallet, less the shims. Once a product parameter set has been selected, the operator presses a release button that sends the pallet in to the process. The pallet passes through the “pre-test” portion of the machine where the presence of an o-ring is detected, and the proper shims are determined through operation. The dimension of a cap that is installed on the pallet is also noted as it will come in to play for the shim selection. If any errors were detected in any part of the process, the pallet will skip any subsequent operations and will return back to the operator in its current state. The pallet then passes in to the assembly station where a robot selects the two shims that were determined by the pre-test station. The shims are placed under an encoder probe where they are verified for dimensional tolerance. The robot places the shim stack on the part, picks up the cap which is on the pallet and places it in a nut runner, which then drives the cap onto the body of the injector at the correct torque and angle. The pallet passes over to the functional test station which performs a steady flow, VOP, guide leak and tip leak tests. If all tests pass thus far, the pallet passes in to a marking station to receive a identification information.



Specifications

<u>Controlled Feature</u>	<u>Control Type</u>	<u>Description</u>
Fuel supply	Programmable through part parameters	The fuel supply is controlled in the range 5 – 58 MPa ±10 KPa during steady flow. Fuel pressure is controlled with a high performance servo valve. The pre-test and functional test stations both take advantage of this feature. The pre-test station also utilizes a dedicated 100 Bar circuit for tip only testing.
Supply Temperature	Programmable through operator interface.	Controlled from 27° C to 40° C ±1° C based on 10 GPM, 55°F externally supplied cooling water. This supply is central to the machine and is constantly circulating the length of the machine even when the machine is idle.
Pin Height	Programmable through part parameters	In the pre-test station, the fixture comes down to meet the pin and then backs off a predetermined distance based on part parameters. This dimension is achieved using a stepper motor controlled actuator and a ½ micron encoder for feedback.
Spring Preload	Programmable through part parameters	The pin height fixture and spring preload fixture both take advantage of an inline load cell to determine when the pin has been met and to close the loop on the spring preload. Both fixtures use encoder feedback to verify the positions for selecting the appropriate shims in assembly.



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Measurements

Feature	Method	Min	Max	Resolution
Mass Flow	Positive displacement Mass flowmeter. Correction for specific gravity at different temperatures.	0.000 Kg/Min	8.500 Kg/Min	0.001 Kg/Min
Valve Opening Pressure (VOP)	MCM designed peak detection module. One or many measurements can be made in a short period of time. If many measurements are made, the standard deviation is also reported to give a "quality" to the measurement.	0 Volts	10 Volts	4 Kpa at 68, 900 KPa scale or 14 Bits.
Guide Leak	Leak decay using pressure transducer and controlled cavity volume.	0 MPa	68900 MPa	4 KPa
Tip Leak	Leak decay using pressure transducer and controlled cavity volume.	0 MPa	68900 MPa	4 KPa
Shim thickness/Cap depth	Motorized encoder and probe. Shim captivation fixture	0 mm	10 mm	0.5 micron
Pin Height	Stepper controlled ball screw actuator with encoder feedback	0 mm	300 mm	0.5 micron
Spring Preload	Inline load cell, compression	0 Lbf	200 Lbf	0.01 Lbf
Cap torque and Angle	Electric driver with angular encoder and torque sensor	0 ft-lbs	20 ft-lbs	0.001 ft-lbs
Body Identification	CCD camera and OCR software decode single character human readable	n/a	n/a	n/a
O-Ring verification	Go/Nogo detection of o-ring presence in an o-ring groove	n/a	n/a	n/a

Options

Although we can make anything to suit your needs, the following have been pre-conceived variations of this machine.

- Redundant or unique stations
- Cell control integration (not required for operation)
- Badge reader for security ID rather than passwords
- Semi-automatic shim dispensing directly to encoder saves robot motion time
- Multiple pallet types for intermingling product types

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