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Refrigerant Gas Recovery Unit

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ABSTRACT

This project addresses the problem of high costs and limited availability of specialized equipment for automotive air conditioning workshops. The main objective was to design and build a multifunctional, economical, and efficient refrigerant gas recovery unit that would integrate the functions of gas recovery, vacuum generation, and pressurized air injection into a single unit. The unit is characterized by its construction with recycled and low-cost materials, utilizing components such as reused compressors and adapted tanks. This approach significantly reduces the required investment compared to commercial equipment. The design consolidated three critical maintenance tasks into a single device, optimizing workflow and reducing downtime during technical interventions. The development followed an applied engineering methodology, prioritizing criteria of functionality, safety, and sustainability. Validation tests demonstrated proper operation in four critical operations: generating a vacuum in the system, recovering and storing refrigerant gas, injecting air for leak detection, and recharging the recovered refrigerant. The project demonstrates the possibility of manufacturing low-cost, specialized equipment that improves efficiency in automotive workshops.

Keywords: coolant; injection; sustainability; manufacturing.

INTRODUCTION

The use of refrigerant gases in air conditioning and refrigeration systems is key to both human comfort and industrial processes. Since the late 19th century, with the first mechanical refrigeration systems, compounds such as ammonia and sulfur dioxide were used. Although efficient at transferring heat, they were toxic or hazardous. In the mid-20th century, Freon emerged, considered safe and stable, but later identified as a cause of ozone layer depletion, leading to the creation of treaties such as the Montreal Protocol (1987) and the search for more sustainable alternatives.

Currently, hydrofluorocarbons (HFCs) are widely used in air conditioning, but their high impact on global warming highlights the need to manage them responsibly. The recovery and reuse of refrigerants has become established as a strategy to reduce emissions and promote sustainability in the sector. Several studies highlight the environmental impact of refrigerants and propose recovery technologies that comply with international standards such as ASHRAE and the Kigali Amendment (2016). However, many commercial solutions are expensive, limiting their access to small or medium-sized workshops. There is still a need for affordable equipment that integrates multiple functions to optimize maintenance.

In this context, this study proposes the design and construction of a refrigerant gas recovery unit capable of performing three functions: refrigerant recovery, vacuum generation, and pressurized air injection. It is proposed that a design based on recycled materials and thermodynamic principles can offer efficient equipment with minimal investment, as an alternative to conventional commercial solutions. The research was conducted using an engineering approach, integrating efficiency, safety, and sustainability criteria. To validate the design, tests were conducted.

JUSTIFICATION

Solution to an efficiency problem: The lack of multifunctional equipment forces staff to constantly

change tools, which creates delays and reduces productivity. The recovery unit will consolidate multiple tasks into a single piece of equipment, optimizing workflow and minimizing downtime.

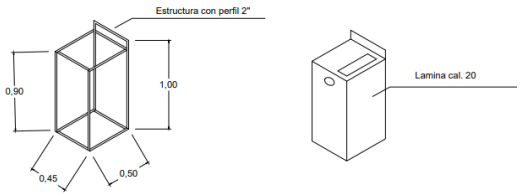
Economic viability: Purchasing new equipment represents a significant investment that is not always feasible for a small or medium-sized business. This project offers an economically viable alternative, leveraging recycled materials and existing components to build a functional tool without incurring significant expenses. Increased profitability: By improving efficiency and service capacity, the company will be able to serve more customers in less time, which will directly translate into increased revenue and market competitiveness.

SCOPE

The project focuses on the design and construction of a recovery unit for the automotive workshop. The unit is multifunctional, combining gas recovery, vacuum, and pressurized air injection into a single unit, with the goal of optimizing diagnostics and service. It is built with recycled materials, prioritizing a low-cost, economical solution.

METHODOLOGY

The recovery unit's base is manufactured using 20-gauge sheet metal, providing an optimal balance between structural strength and ease of handling. This gauge ensures the base can support the weight of the unit's main components, such as the compressor, recovery tank, and control systems, without deforming during operation.



Proyecto: Unidad Recuperadora de Gas Refrigerante Multifuncional.
Universidad Tecnológica de Tlaxcala.

Material resources: Compressor, refrigerant gas storage tank, pressure gauges, valves, filter drier, hoses, condenser, fan, and assembly materials.

Knowledge resources: Knowledge of the operation of air conditioning systems, skills in soldering and component assembly, ability to interpret technical manuals and diagrams.

Financial resources: Limited budget, focused on the acquisition of complementary materials, as the reuse of recycled components is prioritized.

Human resources: The students or team in charge of the project.

FUNCTIONAL TESTS

Test 1: Air Conditioning System Vacuum

A hose was connected to the compressor's suction valve and connected to the pressure gauges in the air conditioning system piping. It was observed that the unit sucked out all the oxygen in the system.

FIGURE 1: Air system vacuum. *Source:* Own, year 2025.

Test 2: Refrigerant gas recovery from the air conditioning system.

A hose from the pressure gauges was connected to the unit's compressor suction valve, then another hose was connected from the compressor's discharge valve to the tank's recovery valve. The unit recovered the refrigerant gas from the system, storing it in the unit's tank for future use.

FIGURE 2: Recovery of refrigerant gas from the air conditioning system. *Source:* Own, year 2025.

Test 3: Air injection into the air conditioning system.

For this test, the pressure gauge hose is connected to the bleed valve on the recovery unit's compressor. This causes the air conditioning system to fill with air, allowing leak detection.

FIGURE 3: Air injection into the air conditioning system. *Source:* Own, year 2025.

Test 4: Charging recovered refrigerant gas from the unit.
The recovered refrigerant gas from the unit's tank was charged into the air conditioning system. The pressure gauge hose was connected to the unit's discharge valve. It was observed that the charge was carried out efficiently.

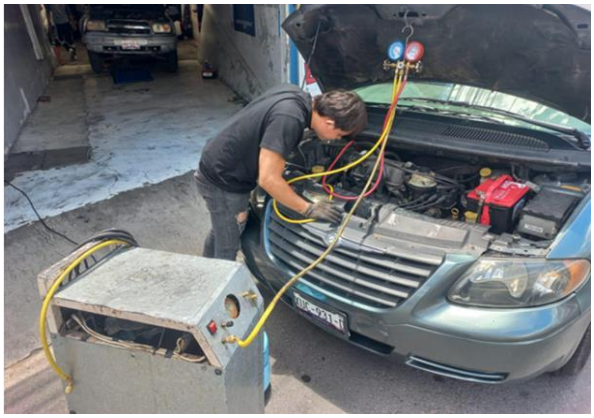


FIGURE 4: Charging recovered refrigerant gas from the unit. *Source:* Own, year 2025.

COMPARATIVE PERFORMANCE ANALYSIS

Función de la Unidad de Servicio	Rendimiento Observado	Comparación con Equipo Especializado
Vacío del Sistema de A/C	Se desarrolló correctamente, succionando el oxígeno, humedad y/o impurezas en el sistema.	El **tiempo** requerido para completar el vacío es **similar** al uso de una **bomba de vacío** dedicada.
Recuperación de Gas Refrigerante	La acción se realizó **satisfactoriamente** almacenando el gas en el depósito para uso futuro.	Cumple con la función de una **bomba de recuperación de gas refrigerante** dedicada, permitiendo el reciclaje del refrigerante.
Inyección de Aire para Detección de Fugas	La unidad cumplió con la función; el compresor trabajó adecuadamente para generar e inyectar aire, posibilitando la detección de fugas.	Actúa como un **compresor de aire** al utilizar su propio compresor para presurizar el sistema, una función esencial para la verificación de integridad del sistema.

RESULTS
Functional tests were conducted on the designed and built Recovery Service Unit to verify its performance in key automotive air conditioning system maintenance tasks. The results are analyzed below in comparison with specialized equipment.

1.1. Functional Tests
The tests performed included:
• Air Conditioning (A/C) System Vacuum: Oxygen was suctioned from the system by connecting the hose to the unit's compressor suction valve and to the A/C system's pressure gauges.

• Refrigerant Gas Recovery: The refrigerant gas was successfully recovered and stored in the unit's tank for future use. The pressure gauges were connected to the unit's compressor suction valve, and the compressor discharge valve to the tank's recovery valve.

• Air Injection: Air was injected into the A/C system by connecting the hose from the pressure gauges to the unit's compressor discharge valve. This function allowed the system to be filled to detect potential leaks, and the unit's compressor was operating properly.

• Recovered Refrigerant Gas Charging: The unit efficiently and successfully injected the stored refrigerant gas from the tank into the A/C system. The tank showed no leaks.

CONCLUSIONS
The Recovery Service Unit proved to be a multifunctional tool that successfully integrates system vacuum, refrigerant gas recovery, air injection for leak detection, and recovered refrigerant charging into a single unit. The vacuum runtime is similar to that of a dedicated vacuum pump, while the other functions are comparable to their dedicated counterparts, enabling efficient and comprehensive refrigerant management, including leak-free storage for reuse.

REFERENCES
[1] Herrera, Julian y Johann Mejia. "IMPLEMENTACIÓN DE UN MANTENIMIENTO CORRECTIVO PARA LA PUESTA A PUNTO DE LA RECUPERADORA DE GAS REFRIGERANTE DE LAS UNIDADES TECNOLOGICAS DE SANTANDER." (2024).

[2] Castro Clavijo, Luz Mery. "Recuperacion del gas refrigerante R-22 clorofluorocarbono, a través de la unidad recuperadora CPS TR 700 y el módulo CRXRM PRO-SET." (2017).

[3] Orozco, C. A., Montoya, J. A., & González, H. A. (2004). Prototipo de recuperacion de refrigerantes. Scientia et technica, 10(26), 91-96.

[4] GÓMEZ, D. E. SISTEMAS DE RECUPERACIÓN DE REFRIGERANTES