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KSR College of Engineering
KSR KALVI NAGAR, TIRUCHENGODE.
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AN AUTONOMOUS INSTITUTION
25 YEARS 2001 - 2026 Celebrating

DEPARTMENT OF MECHANICAL ENGINEERING

IGNITE MECH

MAGAZINE

ACADEMIC YEAR 2024-2025

Chairman Message

Mr. R. Srinivasan,
Chairman,
KSR Educational Institutions

As we stand on the brink of new beginnings and boundless possibilities, I am filled with an immense sense of pride and optimism about what we can achieve together at KSR Educational Institutions. Our founder, Dr. K S Rangasamy, laid a strong foundation rooted in the belief that education is the most powerful tool to transform lives. Carrying forward his legacy, we remain committed to not just educating but empowering young minds to make a meaningful impact in the world.

In today's fast-paced, technology-driven society, the challenges are as dynamic as the opportunities are great. It is imperative for education to transcend traditional learning and encompass the development of holistic, innovative, and critical thinking skills. At KSR, we strive to equip you, our students, with the capabilities to not only adapt to changes but to drive them. We are dedicated to nurturing a generation of leaders, innovators, and thinkers who are ready to take on global challenges with local sensibilities.

Making an Impact is not just a phrase—it's our mission. It's about inspiring each one of you to pursue your passions with determination and a sense of responsibility towards the betterment of society. We encourage you to dream big, push boundaries, and question the status quo. Our campus is a melting pot of ideas where your creativity and ambitions are nurtured, allowing you to flourish in ways you never imagined.

Warm regards,
Mr. R. Srinivasan,
Chairman,
KSR Educational Institutions

Vice Chairman Message

Mr. K. S. Sachin,
Vice Chairman,
KSR Educational Institutions

At KSREI, we stand at the intersection of tradition and transformation, committed to shaping a future driven by knowledge, innovation, and values. While our roots are firmly grounded in a legacy of academic excellence, our vision extends beyond boundaries, preparing students to excel in an ever-evolving global landscape.

Our goal is to create a dynamic learning ecosystem that fosters critical thinking, technological prowess, and ethical leadership. We envision KSREI as a hub of intellectual growth, where students are empowered with 21st-century skills while embracing the timeless virtues of integrity, perseverance, and service.

Looking ahead, we aim to integrate cutting-edge advancements in education, strengthen industry collaborations, and expand global opportunities for our students. With a deep commitment to holistic development, we continue to nurture future leaders who will shape society with wisdom and purpose. Together, we build the future—rooted in values, driven by vision.

Warm regards,
Mr. K. S. Sachin,
Vice Chairman,
KSR Educational Institutions.

Dean Message

Dr. M. Venkatesan
Dean
K.S.R College of Engineering

As a Dean of KSRCE, I actively play my role to facilitate students to become best academicians, researchers and policy makers. I provide a diverse and inclusive work environment to my colleagues and drive them wherever necessary to play a role in getting utmost national and international agencies support Institution. A collaborative and integrated approach towards teaching, learning and research will be emphasized. I strongly believe that the KSRCE team will overcome the constraints facing to deliver the best Engineering services to the society and reach the desired goals.

With Regards,
Dr. M. Venkatesan,
Dean,
K.S.R College of Engineering.

Principal Message

Dr. P. Meenakshi Devi
Principal
K.S.R. College of Engineering

My heartiest welcome to all the young budding Engineers who have joined in "K.S.R. College of Engineering". With the help of highly qualified and dedicated staff members, we will be moulding the students to the required shape which will make them employable. The composite unit of Students, Parents, and Society is our customer. The K.S.R. College of Engineering will strive hard to provide customer satisfaction. In our college, we give top priority to discipline. A series of tests and examinations will be conducted to achieve good performance in the university examinations. An effective Training and Placement (T&P) cell is formed to provide placement to all our students. Importance will be given to extra-curricular and co-curricular activities also.

Excellent infrastructure facilities and good learning atmosphere is an added advantage of this great Institute. I hope all the students admitted here will enjoy the four years of study. Let us all work hard to produce the most competent scientists, engineers, Entrepreneurs, Managers and researchers through Quality Education.

With Regards,
Dr. P. Meenakshi Devi,
Principal,
K.S.R. College of Engineering.

HoD Message

Dr. A. V. BALAN
HoD - Mech
K.S.R. College of Engineering

My heartiest welcome to all the young budding Engineers as the Head of the Department, I'm excited to witness your growth and achievements. This is a time for discovery, learning, and building skills that will shape your future. Our department is committed to providing you with a supportive, innovative, and enriching environment that will challenge and inspire you. We encourage you to take full advantage of the resources, faculty expertise, and peer collaborations available. Don't hesitate to explore new ideas, ask questions, and engage actively in both academic and extracurricular activities. Remember, success isn't just about grades it's about the knowledge you gain, the challenges you overcome, and the networks you build. We are here to guide and support you in your journey.

With Regards,
Dr. A. V. BALAN,
HoD /Mech,
KSRCE.

K.S.R. COLLEGE OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

The Department of Mechanical Engineering is one among the 13 departments functioning in K.S.R. College of Engineering. The department was started in the year 2005 with an approved intake of 60 students, whereas the college was functioning since 2001. The department has excellent infrastructure facilities, well qualified faculty and staff members. It is a recognized Research Centre of Anna University, Chennai. Post graduate degree courses in Industrial Safety Engineering and CAD/CAM are being offered. The Mechanical department is accredited by National Board of Accreditation (NBA), Tier – I. The department has achieved 3 Gold Medals and 22 University Ranks in the examination conducted by ANNA University. Research articles are being published by faculty members regularly in the form of patents (Granted -10, Filed – 40), Copy Rights (Received -3), International & National journals, International & National conferences. Outreach program, Industrial Guest Lectures, National Level Technical Symposium (THROTTLE), National/International Conferences, Value Added Courses, Training related to Placement, Higher Education, Entrepreneurship and Start-Ups are regularly being organized by the department.

VISION

To develop globally competent-mechanical engineers driving technological advancement through sustainable research and socially responsible innovation

MISSION

- Impart industry-focused, value-based education through innovative teaching methods and practical exposure
- Deliver competitive technical education using cutting-edge infrastructure and modern learning environments
- Promote a culture of innovation, research, and ethical responsibility through collaborative efforts for sustainable progress.

Program Educational Objectives (PEOs)

Core Competency: Graduates will analyse, design, and implement sustainable Engineering solutions in diverse engineering domains addressing the needs of society.

Professionalism: Graduates will exhibit impactful leadership and teamwork across diverse cultural and disciplinary environments, contributing positively to the engineering profession

Career Development: Graduates will engage in continuous learning through higher education and research innovations to adapt to emerging technologies and career advancements.

Program Outcomes

- **PO1 Engineering Knowledge:** Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.
- **PO2 Problem Analysis:** Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)
- **PO3 Design/Development of Solutions:** Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)
- **PO4 Conduct Investigations of Complex Problems:** Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).
- **PO5 Engineering Tool Usage:** Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6).
- **PO6 The Engineer and The World:** Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).
- **PO7 Ethics:** Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
- **PO8 Individual and Collaborative Team work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
- **PO9 Communication:** Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
- **PO10 Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
- **PO11 Life-Long Learning:** Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

Program Specific Outcomes (PSOs)

PSO1: Mechanical System Design and Analysis:
Apply fundamental principles of mechanics, thermodynamics, and materials science to design, analyze, and optimize mechanical components and systems.

PSO2: Manufacturing and Automation:
Utilize modern manufacturing techniques, automation, and computer-aided tools to develop efficient and sustainable production processes.

Student Publication

DEVELOPMENT OF A MECHANIZED RICE TRANSPLANTER

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ABSTRACT

The increasing demand for efficient rice cultivation has driven the need for mechanized transplanting systems. This study focuses on the development of a mechanized rice transplanter to improve efficiency, reduce labour dependency, and ensure uniform transplanting. The system was designed, fabricated, and tested in field conditions to evaluate its performance. Parameters such as transplanting speed, seedling survival rate, and uniformity were analyzed. The results indicate that the mechanized transplanter significantly improves transplanting efficiency while reducing manual labour requirements. The study highlights the potential benefits of mechanization in rice farming and suggests future improvements for widespread adoption.

KEYWORDS : Mechanized transplanting, Rice transplanter, Efficiency, Labour reduction

I. INTRODUCTION

In order to transfer rice seedlings onto a paddy field, a rice transplanter is a specialized equipment equipped with a transplanter mechanism (often exhibiting some kind of reciprocating motion) powered by the live axle. One of the world's main food grain crops is rice.Lowland rice production requires a lot of labor, in contrast to upland row crops. Despite the widespread perception that India has an abundance of agricultural labor, there is a shortage of qualified agricultural workers during the busiest transplanting seasons. The yield decreases if this operation is not completed on time.

[1] Given this, it is imperative that this

reduces labor requirements by 75–80% while producing a yield comparable to manual transplanting. The self-propelled and manual transplanter lowers transplant costs by 45–50%. India's average rice yield is only 2.09 t/ha, while the global average is 3.91 t/ha and Japan's is 6.58 t/ha. [2] Over 60% of farmers in Asia own less than two hectares of land. Therefore, in emerging nations, technology for tiny holding sizes is crucial. A rice transplanter is a specialist transplanter used in paddy fields to grow rice seedlings. About 4-5 acres may be transplanted in a day by a single transplanter (2 rows at a time), which is far more efficient than the conventional method. 80000 plants per acre is the recommended plant population, and farmers can transplant 80000 to 120000 plants per acre with the aid of a transplanter. [3]

II. LITERATURE REVIEW

S. Pradhan and S.K. Mohanty presented, Transplanting of paddy is very tedious job mostly done by female workers during Kharif season andby 2020 there would be 50 percent women against 42 percent at present. Manual hand transplanting consumes a lot of energy and time and full of fatigue, but the poor socio-economic condition of the farmers does not allow them to adopt power operated transplanter. Transplanting operation by different research centers have been developed as 2 row, 3 rows, 4 row paddy transplanter.[7]

According to M. V. Manjunatha and b. G. Masthana Reddy, research on the viability of mechanizing transplanting procedures in paddy crops in an effort to lower cultivation costs was carried out at the Agricultural Research Station in Gangavathi, Karnataka state, between 2002 and 2004. For this, an eight-row self- propelled paddy transplanter was employed. The mechanical transplanter operated in a very satisfactory manner. [8]

Published by Chetan Chaudhari, this study is predicated on the fundamental design of the CAD-CAM software and the theoretical development of a mechanical rice transplanter. After careful consideration, a mechanized rice planter was created. The planting finger, gear drive, and cushioned wheel design are crucial components. According to the rice transplanter's methodology, he worked on a few calculation areas and discovered that, for the same planting area, it would be at least 95% more efficient than the manual planting method. Because of the relative driving between the wheel and spur gear, the design will be a little more complicated. [1]

III. OBJECTIVE

1. Creating a basic system is the first step in designing a rice transplanter.
2. It is less expensive and easier to handle.
3. Although an engine-powered rice transplanter machine is also an option, we

have built a manual rice transplanter to make it easier to operate and less expensive.

The procedure of mechanically transplanting rice involves utilizing a self- propelled rice transplanter to move immature seedlings that have been raised in a mat nursery. One acre of transplanting requires eight to twelve laborers in traditional manual transplanting methods.

4] However, three persons may transplant up to four acres in a day if they employ a self-propelled rice transplanter. CAD model of a rice transplanter proposed.

IV. EXPERIMENTATION

The research involved designing and fabricating a mechanized rice transplanter, followed by field testing to assess its performance. The key objectives were:

To develop a functional prototype with essential transplanting mechanisms.

To test transplanting accuracy, efficiency, and effectiveness in various field conditions.

To compare the machine's performance with traditional manual transplanting methods.

V. PROCEDURE

The study followed a structured approach, including:

1. Conceptual Design: Initial sketches and technical drawings were created.

2. Fabrication: The transplanter was built using lightweight, durable materials.

3. Seedling Preparation: Healthy seedlings were grown in trays for mechanized transplanting.

4. Field Testing: The machine was operated in a prepared paddy field, and key parameters were recorded.

VI. Data Collection: Transplanting speed, plant spacing, seedling survival rate, and labor requirements were analyzed. SYSTEM DESIGN

The mechanized rice transplanter consists of several key components:

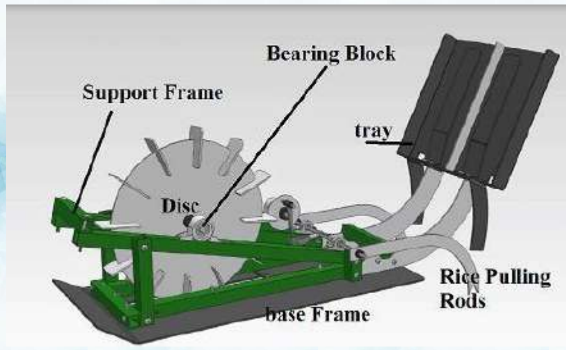
Seedling Tray Feeder: Holds the seedlings and feeds them into the transplanting mechanism.

Pickup and Placement Mechanism: Uses a mechanical arm or rotary system to pick seedlings and plant them at uniform spacing.

Drive System: Powered by an engine or motor, providing movement across the field.

Depth Control Mechanism: Ensures seedlings are planted at the correct depth for optimal growth.

Frame and Structure: Lightweight and durable to ensure ease of operation.



VII. LIMITATIONS OF OLD METHOD

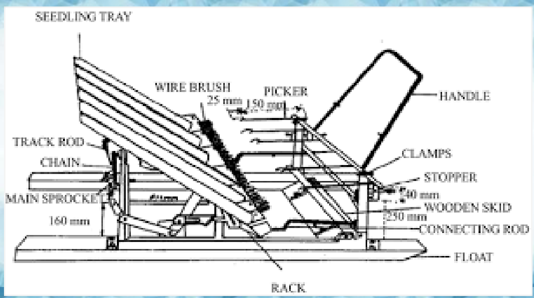
Transplanting is tedious and time-consuming (up to 30 man days/ha)

1. Back issues are a health risk for plantation workers.
2. It's challenging to get enough workers during busy times to plant on schedule.
3. It is challenging to maintain uniform

plant density and ideal spacing, particularly when using contract labor and unpredictable transplanting.

4. ow plant density combined with area-based contract transplanting reduces yields.

5. The potential risk that seedlings, particularly those of contemporary kinds, may grow too old in rain-fed places before the field is prepared for planting.



VIII. ADVANTAGES OF RICE TRANSPLANTER

Efficient use of resources by saving on labour, cost saving, water saving.

1. Promptly moving seedlings of the ideal age.
2. With two to three seedlings per hill, it guarantees even spacing and ideal plant density.
3. Greater productivity in contrast to conventional techniques.
4. Less transplant shock, early seedling vigor, and uniform crop maturity that enable prompt harvest and lower harvest losses
5. Creates jobs and other revenue streams for young people in rural areas by offering specialized services in mechanical transplanting and nursery growing.
6. Better job prospects for young people in rural areas by fostering the growth of custom service enterprises.
7. Deals with the labor shortage issue.
8. Boosts the net income of farmers.

IX. RESULT

The performance evaluation of the mechanized rice transplanter yielded the following results:

Increased Efficiency: The transplanter reduced transplanting time by 50% compared to manual methods.

Uniform Seedling Spacing: Improved accuracy in plant placement led to better crop growth.

Higher Seedling Survival Rates: Mechanized transplanting reduced transplanting shock, improving plant survival.

Reduced Labor Costs: The system required significantly fewer workers, lowering overall labor expenses.

Economic Viability: Although the initial investment was high, long-term benefits such as reduced labor costs and increased yield made mechanization cost-effective.

X. CONCLUSION

Rice paddy transplanter is highly recommended for the local farmers of however previously the farmers need to be instructed regarding its proper operation since mechanized transplanter requires mat – type nursery.

1. A mechanical paddy transplanter will greatly facilitate the rice transplanting process because the farm land in the area is of average size.
2. It would also lessen farmers' heavy reliance on workers for transplants.
3. It is simple to connect the transplanter machine to a weed-removal mechanism, which may aid farmers in the paddy plantation weeding procedure even more.

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DEVELOPMENT OF COOLING JACKET USING THERMOELECTRIC DEVICE

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ABSTRACT:

Due to metabolic heat generation from our body, we are very uncomfortable both in cold and hot weather, especially when we work hard. In cold weather we wear jacket to have more comfort. We can't have much comfort when we use jacket. Unlike cold weather, in hot weather we don't have such an alternative solution for comfort. If there is a jacket cooler, then it will be comfort both in cold and hot weather. A thermoelectric cooling prototype jacket has been fabricated. An innovative evaporative type heat sink has been designed and fabricated. A control switch to regulate the flow of current through the circuit thus to control the heat capacity of the module has been prepared. The performance of the prototype jacket was evaluated by analytical and numerical methods. Ansys 9.0 was used for numerical analysis. Keywords: Thermoelectric cooler, Cooling jacket, Control switch, Heat sink.The development of a cooling jacket utilizing thermoelectric devices presents an innovative solution for temperature regulation in various applications, ranging from wearable technology to electronic cooling. Thermoelectric devices, based on the Peltier effect, offer the ability to transfer heat efficiently from one side to another when an electric current is applied. This study explores the integration of thermoelectric modules into a wearable cooling jacket designed to provide active cooling for the body or sensitive equipment. The cooling system relies on the controlled operation of thermoelectric modules, which absorb heat from the wearer or device surface and dissipate it through a heat sink or fan mechanism. Key design considerations include the selection of thermoelectric materials, power supply management, efficient heat dissipation, and insulation. While challenges such as low energy efficiency and heat removal from the hot side of the modules remain, advances in thermoelectric materials and hybrid cooling systems offer promising prospects for improved performance. This technology has the potential to revolutionize fields such as wearable cooling systems for athletes, emergency

1. INTRODUCTION

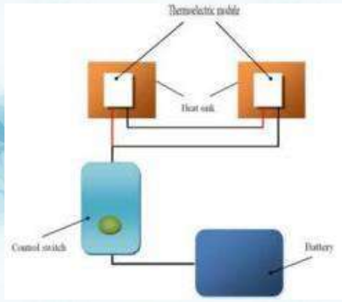
Thermoelectric cooler or Peltier cooler is a solid-state heat pump that uses the Peltier effect to move heat. Thermoelectric elements are so small and light that they have been used in many fields [1]. A cooling

evice for personal use outdoors is a necessity under very hot atmosphere. The purpose of this project was to make a prototype of cooling jacket that is refrigerated by a thermoelectric element driven by battery and to investigate the possibility of a personal cooling unit for outdoor use. A literature survey is conducted to review the proceedings along this way. The personal care apparels are given due care in the review. Here, mainly two type reviews are conducted. One review is strictly restricted on the papers published on the journals. There are many papers on thermoelectric elements. But there are only a few papers on applications of thermoelectric modules. There are headgears refrigerated by thermoelectric modules [2]. But unfortunately there is no cooling jacket refrigerated by thermoelectric modules. But there are many cooling jackets with different methods for cool them. One is phase change material based and another is a fan cooled one. The design of a heat sink suitable for the efficient operation of the thermoelectric module is necessary. During the operation heat will be continuously rejected at the hot end. Thus there will be a chance for accumulation of heat at the hot end. Thus, due to the accumulation of heat at the hot end the temperature difference between the cold end and the hot end will be more. This will enhance the heat transfer rate from the hot end to the cold end, i.e., reverse flow of heat from hot end to cold end. So to operate the thermoelectric module more efficiently there must be a heat sink at the hot end. The thermoelectric module with heat sink must be kept inside the Jacket to cool the inside of the jacket. So it is not possible to use an ordinary air cooled type heat sink or complicated water cooled type heat sink. An innovative type heat sink must be designed for this purpose. A simple Evaporative cooling type heat sink has been designed for this purpose. The electrons arethe heat carries in the thermoelectric module. To control the heat carrying capacity or the temperature of the cold end of the thermoelectric module the number of electrons passing through the module must be regulated.

2. PROPOSED MODEL

The suitable thermoelectric modules are selected according to the selection procedure described [3]. The model presented here has two thermoelectric modules. Each thermoelectric module can absorb approximately 6 watts. For a typical person, for 70 W heat load of moderate work, there must at least 12 modules (70/6 = 12) [4]. More number of modules can be used depends upon the severe of activity. But unfortunately due to some constraints only two modules are used in the model. The modules are connected electrically in series to pass equal amount of current through all the modules. The components included in the prototype are as follows, (i) Two thermoelectric modules (ii) Two heat sinks with water reservoir (iii) A control switch

(iv) A DC power source. The modules are connected to a DC power source via a control switch. The control switch regulates the flow of current through the modules in the circuit. To measure the temperature at the surface of the cold end a temperature sensor is attached into the surface. The temperature can be read from the display provided on the control switch. Each thermoelectric module has its own heat sink. The heat sinks are evaporative cooling type. There is a common water reservoir to supply water in to the heat sink from where the water gets evaporated by receiving heat from the module.



3. OPERATION WORKS

3.1. Research and Selection of Thermoelectric Materials and Modules

Objective:

- Identify and select the appropriate thermoelectric modules based on cooling requirements.

Operations:

- Study the thermoelectric materials (e.g., bismuth telluride, silicon-germanium) to identify suitable properties like efficiency, cost, and cooling capacity.
- Choose commercially available **Peltier modules** (e.g., **TEC1-12706**) based on power input and cooling output specifications.

3.2. System Design and Conceptualization Objective:

Define the cooling requirements based on the intended application (e.g., wearable jacket for body cooling, electronics cooling, etc.).

Task:

Determine the cooling capacity required for the jacket (how much heat needs to be removed from the wearer or device).

Choose the thermoelectric module (Peltier device) based on its cooling power (usually measured in watts).Design the jacket's structure and layout, considering where to place the thermoelectric devices (e.g., in panels or integrated into fabric layers).

3.3. Selection of Thermoelectric Modules Objective:

- Choose the right thermoelectric material and module based on efficiency, power consumption, and desired cooling performance.

4. MATERIAL SELECTION:

- Peltier devices typically use **bismuth telluride** or **lead telluride** as the primary materials for the thermoelectric elements.
- **Module specifications**: Select thermoelectric modules with a suitable **Seebeck coefficient** and **thermal conductivity** for maximum efficiency.
- Consider the **voltage and current** requirements of the thermoelectric module and the power supply options.

5. POWER SUPPLY AND CONTROL CIRCUIT

Objective:

- Design and implement an efficient power supply system for the thermoelectric modules.

Task:

- Select an appropriate **power source** (e.g., **DC battery** or **external power supply**) to provide the required current and voltage.
- Design a **control circuit** to regulate the **input current** and **temperature feedback** (this could involve using a **thermistor** or **thermocouple** to monitor the jacket temperature).

- Implement **temperature regulation** through a **feedback loop**, adjusting the thermoelectric device's power to maintain desired temperatures.

6. PROTOTYPING AND ASSEMBLY

Objective:

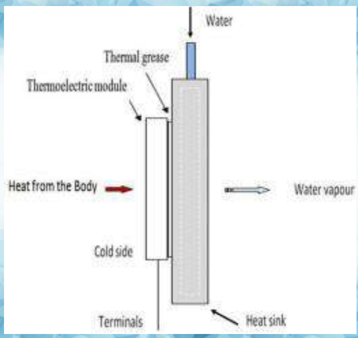
Assemble the cooling jacket prototype and perform initial tests.

Task:

- Assemble all components: thermoelectric modules, heat sinks, fans, power supply, and insulation.
- Test the **structural integrity** of the jacket to ensure comfort and mobility.
- Use **thermal sensors** and **multimeters** to verify the power consumption and temperature control capabilities of the jacket.

7. OPERATION OF COOLING JACKET

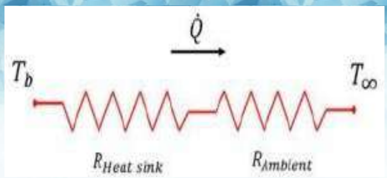
The operation of the model presented here is described below. All the components are connected in the manner mentioned above. The components are mainly two coolers with heat sinks, a battery and a control switch. When the switch in the control switch is put on, the current from the battery flows through the cooler via control switch. The **control switch** gives a pulsating current from the control switch [5]. The control switch is used to control the temperature of the faces. By adjusting the potentiometer in the control switch, the temperature of the faces can be altered.

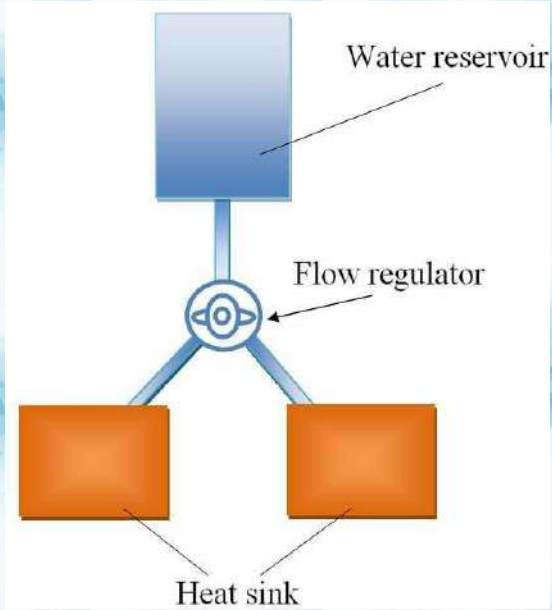


8. DESIGN OF HEAR SINK

The main parts of this evaporative cooling type heat sink are as follows:

- Heat sink with a piece of sponge attached into it
- (ii) A container to store enough water
- A regulator to control the flow of wate





The total thermal resistance of the heat sink and the ambient air is taken as 2.42 oC / The thermal interface material used here is heat sink compounds. There is a carrier liquid such as silicone (or other synthetic fluid) that is filled with micro fine particles of

hermally conductive materials such as zinc oxide, aluminum oxide, boron nitride, or silver. Thermal conductivity ranges from 0.8 W/m-K to 7.5 W/m-K. The amount heat rejected at the hot end of the module is around 14 W, 50.4 kJ / hr. Therefore, the amount of water required to operate one thermoelectric module for four hours is

79.01 ml.

9. GOVERNING EQUATIONS OF THERMOELECTRICITY

In a thermoelectric analysis the equations of heat flow

- !-

!" # $.% - &' (1.1)

and of continuity of electric charge

$.() # !*

!"+ - 0 (1.2)

are coupled by the set of thermoelectric constitutive equations

% - -Π..) / -0..$1 (1.3)

) - -2.. 34 / -5..$16 (1.4)

and the constitutive equation for a dielectric medium

* - -7..4 (1.5)

Where,

- = density kg/m3

 = specific heat capacity, J/kg-K 1 = absolute temperature, K

&' = heat generation rate per unit volume, W/m3

% = heat flux vector, W/m2

) = electric current density vector, A/m2 4 = electric field intensity vector, V/m

* = electric flux density vector, C/m2

-2. = electrical conductivity matrix, S/m

-0. = thermal conductivity matrix, W/m-K

-5. = Seebeck coefficient matrix, V/K

-Π. = T-5. - Peltier coefAicient matrix, V

-7. = dielectric permittivity matrix, F/m

In the absence of time-varying magnetic fields, the electric field ***E*** is irrotational ($C4

- 06,

and can be derived from an electric scalar potential D:

4 - /E- (1.6)

Substituting Eqns. (1.3)-(1.6) into Eqns. (1.1)-(1.2) produces a system of coupled equations of

thermoelectricity:

- !-

!" # $.3-П..)6 / $.3-0..$16 - &' (1.7)

$.(-7..$!F

!G+ # $.3-2..-5..$16 # $.3-2..$-6 - 0 (1.8)

Where the heat generation term %' in Eqn. (1.7) includes the electric power).4 spent on Joule

heating and on work against the Seebeck field -5.$1 .

Note that the displacement current !*

!" associated with the capacitive effects has been included

in the system of equations for completeness, even though it may not play a significant role in

thermoelectric applications unless fast transient processes are considered.

10. FINITE ELEMENT FORMULATION

The system of thermoelectric finite element equations can be obtained by applying the Galerkin FEM procedure [7] to the coupled equations derived in the previous section.

This technique involves

(a) approximating the temperature T and electric scalar potential - over a finite element as:

1 - H.IJ (1.9)

- - H.-J (1.10)

Where,

N = vector element shapes functions.

1J = vector of nodal temperatures

-J = vector of nodal electric potentials

(b) Writing the system of Eqns. (1.7) and (1.8) in a weak projective form, (c) integrating the projective equations by parts, and (d) taking into account the Neumann boundary conditions.

Without further elaboration, the resulting system of thermoelectric finite element equations is:

K __ 0

0 FFLM1'J

-'JN # KO ___0

OF- OFFLM1J -JN - MP PQ PJ R N

Where the element matrices and load vectors are obtained by numerical integration (using Gauss quadratures) over the element volume V:

O___- SV $H.-0..$HTU Thermal stiffness matrix

OFF - SV $H.-2..$HTU Electrical stiffness matrix

OF- - SV $H.-2..-0..$HTU Thermal stiffness matrix

___ - - SV CXHTU Thermal damping matrix

P - Vector of combined heat generation loads

PQ - SV $H.-П..)TU Peltier heat load vector PJ - SVHY.)TU Electrical power load vector

I - electric current load vector

Thermal loads (P) can be in the form of imposed temperature, point heat flow rate, surface heat flux, convection, or radiation, as well as body heat generation rate for causes other than electric power dissipation (accounted for in PJ). Electrical loads (*I*) can be in the form of imposed electric potential and point electric current. Linear electric circuit components (resistors, capacitors, and voltage or current sources) can be connected to the finite element model to simulate passive and active electrical loads. The ANSYS input of material matrices [λ], [σ], [α], [ε] is in the form of their diagonal terms, i.e. material coefficients along the x, y, z axes. This input can be combined with an arbitrarily oriented element coordinate system toaccount for an alternative material orientation. Electrical properties are input as resistivity and

internally converted into conductivity [σ], which is the conductivity evaluated at zero temperature gradient ($T = 0). The input [λ] is the thermal conductivity evaluated at zero electric current (**J** = 0). All material properties can be temperature dependent. In particular,Thomson effect is taken into account by specifying temperature dependent Seebeck coefficients [α]. The global matrix equation is assembled form the individual finite element equations, and is non symmetric like Eqn. (1.11). Since the thermal load vector depends on the electric solution, the analysis is non-linear (steady state or time- transient) and request at least two literations to converge. The temperature offset from zero to absolute zero should be specified if temperature is in units other than Kelvin. The solution yields temperatures (1J6 and electric potentials (-J6 at unconstrained nodes, or reactions in the form of heat flow rate and electric current at nodes with imposed temperature and electric potential respectively. The temperature

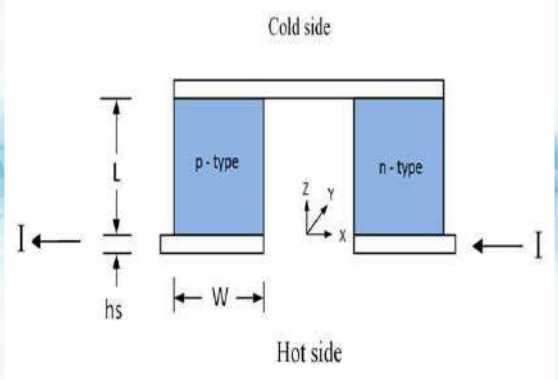
gradient and electric field are calculated as

$1 - $H.1J (1.12)
4 - /$H.-J (1.13)

11. RESULT AND DISCUSSION

The proposed model is fabricated. The analytical and numerical analyses are done. In order to do numerical analysis, finite element analysis (FEA) software Ansys 9.0 is used. A couple thermoelectric elements is taken for the analytical and numerical analysis. The material

properties of the thermoelectric module are given in the Table 3. The material properties for the analysis were evaluated at the average cooler temperature of 27°C.



The dimensions of the semiconductor elements are as follows length and width are one millimetre and the cross sectional area is one square millimetre. The cold end

temperature 1Z is 273 K and the hot end temperature 1[is 327 K.

12. ANALYTICAL METHOD

The analytical analysis is done using the above values [8]. The total resistance and the overall

conductance for both elements are 0.00203 Ω and 2.5 - 10`- W/0C respectively. The figure of

merit and the coefficient of performance (COP) are 0.0027 O`- and 0.317

respectively [9]. The

corresponding current to produce above mentioned COP is 4.31 A. The cooling produced per couple at the cold face when the above current is passed through the circuit is 0.394

W. They

have to be connected in series to increase the heat capacity of the module. Therefore the required number of pairs is 16 for a total heat capacity of 6 W.

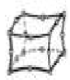
13. NUMERICAL METHOD

A three dimensional steady-state thermal-electric analysis is carried out to evaluate the performance of the cooler using a combination of SOLID226 and SOLID227 elements. As it is **Volume 05 MES Journal of Technology and Management January 2013 92** done in the analytical analysis a couple of thermoelectric cooler is taken for analysis. The

elements used for discretisation of the module are given in the table 4. The current,

I = 4.31 A

taken from the analytical solution is used in the numerical analysis. The calculated temperature distribution in the cooler

SOLID 226 Coupled field Hexahedral	SOLID 227 Coupled field Tetrahedral
	

14. DISCUSSION

The cooling effect produced per couple at the cold end was 0.394 W by both analytical and

numerical method when the current passed through the circuit was 4.31 A. Thus the number of couples required to produce a cooling effect of 6 W is around 16. The maximum value of current which can be passed through the circuit is limited to 2 A. The number of modules used in the prototype is two. The thermoelectric modules used in the prototype have 31 couples in each module. The total cooling effect produced by the modules may be around 12 W.

15. CONCLUSIONS

A jacket for safe guarding a person from hot atmosphere is the objective of this project.

The

thermoelectric refrigeration is the method adopted here. A prototype of the proposed cooling jacket is designed and fabricated. The following are main components to fabricate the proposed cooling jacket. The thermoelectric modules which work on the principle of Peltier effect are selected for the cooling jacket for refrigerating effect. To order to operate the thermoelectric module efficiently, the heat accumulates at the hot end must be dissipated. A heat sink with a **Volume 05 MES Journal of Technology and Management January 2013 93** water reservoir is designed and fabricated for this purpose. The thermoelectric module must not

be overloaded. The temperature at the cold end can be varied by adjusting the flow of current

through the circuit. A control switch is designed and assembled to do this. The components must be suitably concealed in a jacket. A suitable fabric jacket is designed and prepared for this. The works done are properly ordered and documented in the thesis.

16. SUGGESTIONS FOR FURTHER WORK

Here, a battery powered cooling Jacket is introduced. A battery is a limited source of power. It must be recharged regularly. Solar cell can be used to recharge the battery. Paper type solar cell is available in the market which is suitable for this application. The crystal type solar cells are heavy but amorphous cells are lighter. There is scope for more innovation and modifications.

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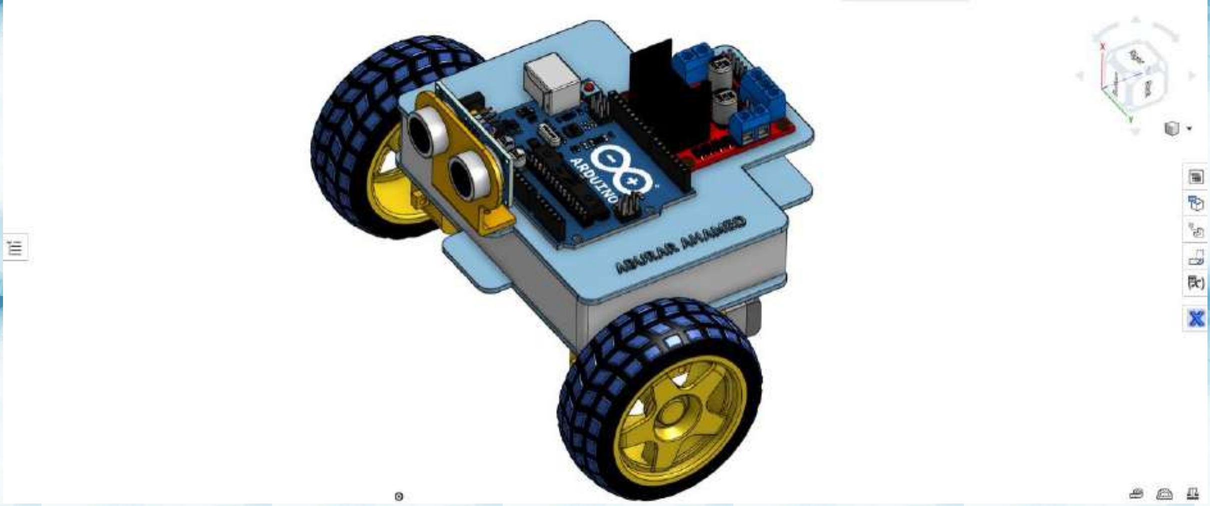
Student Activities



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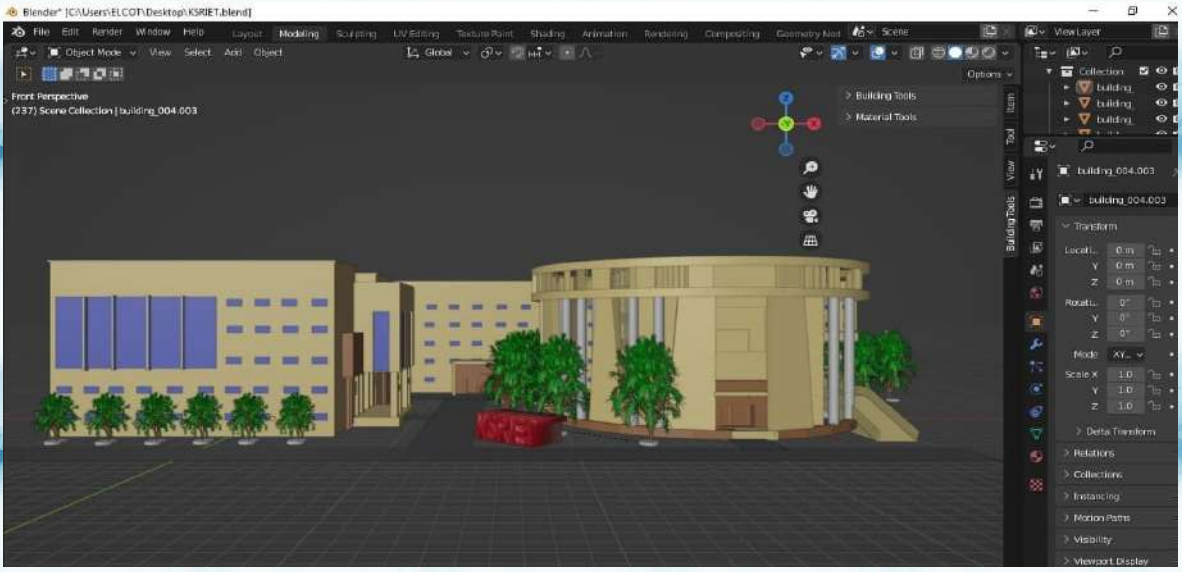

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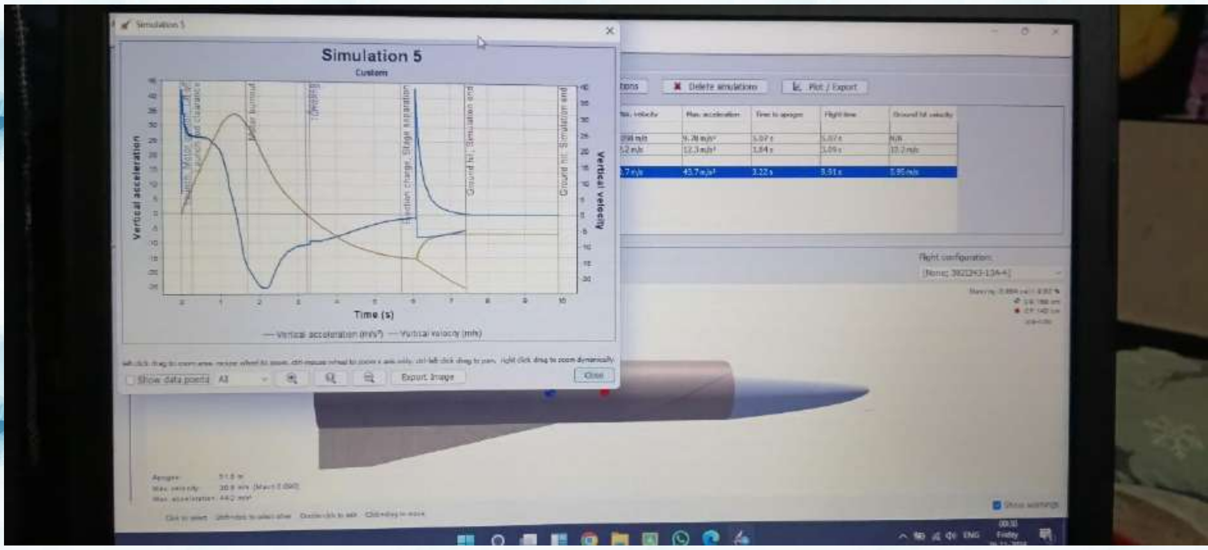

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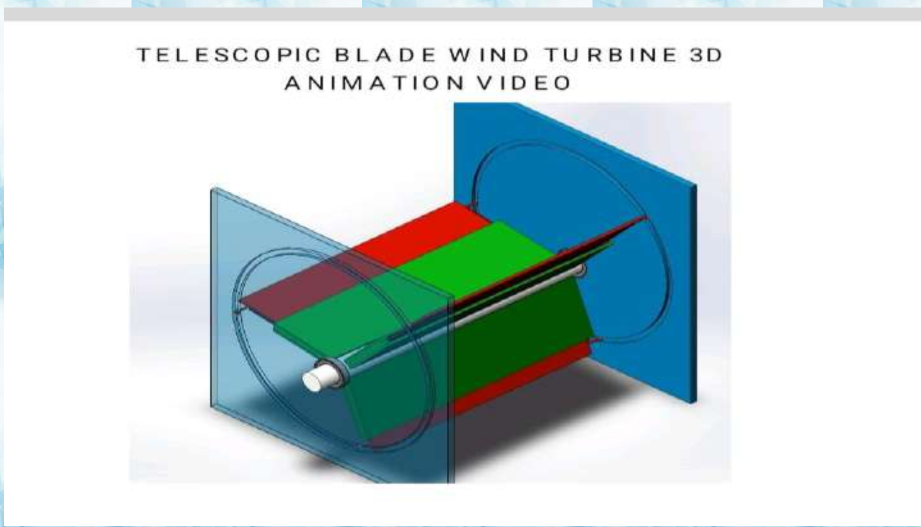

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