ENGINEERING PORTFOLIO

VARAD PRAMOD LAD

vlad3@asu.edu • LinkedIn/varadlad

M.S. Mechanical Engineering, Arizona State University, USA
B.Tech. Mechanical Engineering, Sanjay Ghodawat University, India

ABOUT THIS PORTFOLIO

Hello, my name is Varad Pramod Lad. This portfolio aims to supplement my resume by presenting some selected projects I developed during my undergraduate and graduate studies. The most important purpose of this portfolio is to highlight my real-world knowledge and skills through hands-on projects that I did throughout my career. As you will see, during my education in Mechanical Engineering, I got involved with different projects at various levels of knowledge. For each project, I provide a description, the "What? How? and Result?" to better understand the overall project, and pictures. If you have any questions about any project, feel free to contact me by email, vlad3@asu.edu.

EDUCATION

Master of Science
Mechanical Engineering

Bachelor of Technology
Mechanical Engineering

EXPERIENCE

Project Engineer - Mechanical

R&D, Module Process Engineer

Mechanical Engineering, MICU-TSMC Fab 21

NASA L'SPACE Project Specialist

LETTER OF RECOMMENDATION

Rayn INNOVATIONS

To Whom it May Concern,

I am sending this letter for the purpose of an R&D internship evaluation. I had the honor of mentoring and supervising Varad Lad, Masters in Mechanical Engineering, during his R&D internship at Rayn Innovations from January 2024 – May 2024. He is diligent, enthusiastic, and always ready to take on new challenges. He has quite a bit of experience in the Solar and Battery field, and overcame all challenges he has faced within his project.

His duties included, but were not limited to the following;

- Conduct routine and non-routine chemical analysis of materials and product developments, strictly adhering to provided safety precautions, procedures and training
- Document and report all experimental and test results in a well-maintained laboratory notebook
- Identify processing problems or areas of improvement and recommend solutions
- Edited and contributed to proposals

His primary duty was to research and develop a design of experiments (DOE) for aluminum doped zinc oxide (AZO) thin films for various photovoltaic applications. He went through many processing iterations and successfully developed a working chemical process for AZO deposition. He also assisted in characterizing these films for further study and quality control by characterizing these materials.

Varad has accomplished all his deliverables agreed upon at the start of his internship. His last deliverable is sending a report outlining the experimental procedures and the characterization analysis.

Regards,

Nicole Ray
Nicoleray@rayninnovations.com

LETTER OF RECOMMENDATIONS

Marketech International Corporation USA

23040 N 11th Ave. Building 1, Unit 100, Phoenix, AZ 85027
Office: (623) 248-7766, Fax: (623) 259-9966

Subject: Letter of Recommendation
August 22, 2023

To Whom It May Concern,

I am writing to strongly recommend Varad Lad for a position at your organization. During his internship at Marketech International Corp. USA (MICU), Varad worked directly on the TSMC F21 Tool Interconnect Project exhibiting an exceptional blend of technical ability, collaboration, and commitment to excellence.

Here are some highlights of Varad's accomplishments and contributions:
1. Tool Installation and Construction: Varad displayed expertise in tool installation and construction in the semiconductor industry. He strictly adhered to regulatory standards such as OSHA, ASTM, NFPA, and IMC, ensuring high-quality performance and safety.
2. Budgeting & Time Management: Working closely with the team, Varad helped ensure that our projects remained within budget and were delivered on time, showcasing exemplary project management skills.
4. Communication & Reporting: With an ability to communicate effectively, Varad kept all stakeholders informed of project status and quickly addressed challenges. Varad's coordination with subcontractors and scheduling proficiency contributed to a well-organized project execution.
5. Pre-construction Coordination: Varad was vital in pre-construction planning, demonstrating foresight and thorough preparation.

Varad Lad is a dedicated and versatile professional, ready to take on the challenges of the ever-evolving field of project engineering and semiconductor. His willingness to learn, coupled with his technical acumen, makes him a valuable asset to any organization.

I unreservedly recommend Varad Lad for any role within this industry. He possesses the qualities and expertise needed to succeed and contribute positively to any project or team. Please feel free to contact me if you would like further information.

Sincerely,

Hand, Travis Lee
Project Engineer and Coordinator
Travishand@us.micb2b.com
Mobile: +1 (912)288-2647

Yu, Alex
Project Manager
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SEMICONDUCTOR PROJECTS

✓ Deposition Rate Optimization for Semiconductor Materials

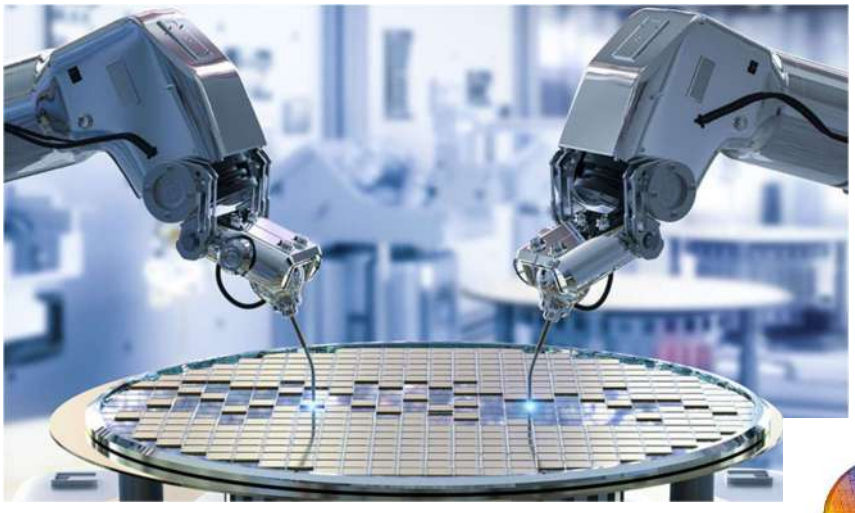
WHAT?

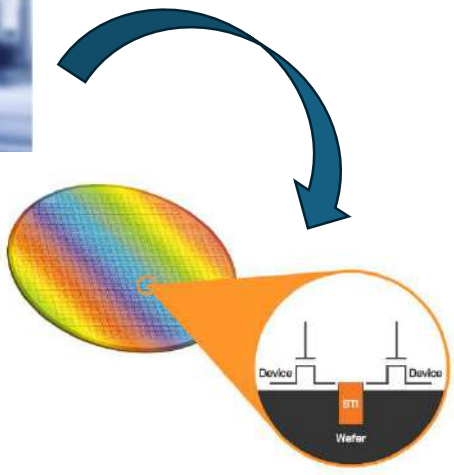
Optimization of the semiconductor deposition rate is critical for improving quality and reducing manufacturing costs.

- The deposition rate affects properties like film thickness, uniformity, and purity that impact device performance and yield.
- Faster deposition can increase production throughput and lower capital costs.
- There is a complex relationship between process parameters like temperature and deposition rate that is difficult to optimize manually.

Bayesian optimization is an advanced machine learning technique to efficiently search high-dimensional parameter spaces.

- It constructs a probabilistic model to represent belief over the objective function.
- The model is used to determine informative sample locations to evaluate.
- It balances exploration to improve the model and exploitation to find the optimum.





HOW?

An empirical deposition rate model was defined as a function of temperature and plasma power.

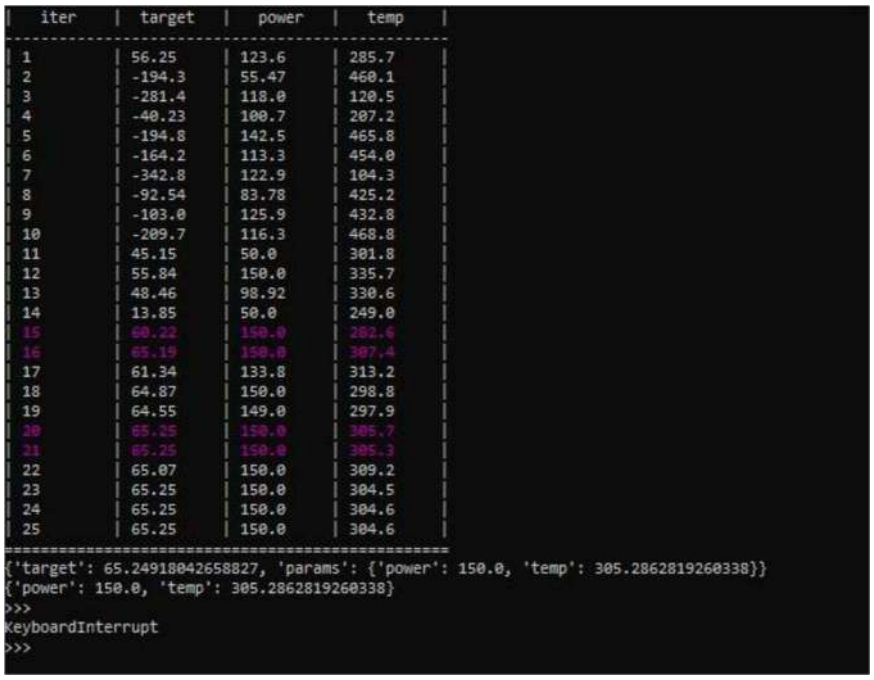
- The model has a quadratic relationship between temperature and deposition rate.
- Deposition rate increases linearly with higher plasma power.
- The model allows evaluating deposition rate at different parameter settings.

A Gaussian process probabilistic model was constructed to represent belief over the deposition rate.

- Gaussian processes can capture complex nonlinear functions.
- The GP model is iteratively updated to improve accuracy.
- The model guides the selection of optimal parameters to evaluate next.

```python
import numpy as np
from bayes_opt import BayesianOptimization


# and plasma power
def deposition_model(temp, power):
    rate = 5 + 0.1*temp + 0.2*power - 0.01*(temp-300)**2
    return rate

# Bayesian optimization to maximize deposition rate by
# tuning temperature (100 to 500 C) and power (50 to 150 W)
bo = BayesianOptimization(deposition_model, {'temp':(100, 500),
                                             'power':(50, 150)})

bo.maximize(init_points=10, n_iter=15)

print(bo.max) # Print optimized deposition rate
print(bo.max['params']) # Print optimal parameters
```

RESULTS?



iter	target	power	temp
1	56.25	123.6	285.7
2	-194.3	55.47	460.1
3	-281.4	118.0	120.5
4	-40.23	100.7	207.2
5	-194.8	142.5	465.8
6	-164.2	113.3	454.0
7	-342.8	122.9	104.3
8	-92.54	83.78	425.2
9	-103.0	125.9	432.8
10	-209.7	116.3	468.8
11	45.15	50.0	301.8
12	55.84	150.0	335.7
13	48.46	98.92	330.6
14	13.85	50.0	249.0
15	60.22	150.0	282.6
16	65.19	150.0	307.4
17	61.34	133.8	313.2
18	64.87	150.0	298.8
19	64.55	149.0	297.9
20	65.25	150.0	305.7
21	65.25	150.0	305.3
22	65.07	150.0	309.2
23	65.25	150.0	304.5
24	65.25	150.0	304.6
25	65.25	150.0	304.6

```
{'target': 65.24918042658827, 'params': {'power': 150.0, 'temp': 305.2862819260338}}
{'power': 150.0, 'temp': 305.2862819260338}
>>>
KeyboardInterrupt
>>>
```

The optimized deposition rate was 65.25 Å/s, a 30% improvement over the baseline.

- The higher deposition rate can enable faster production and lower costs.
- Film quality will also benefit from the optimized parameters.

Bayesian optimization efficiently searched the parameter space to determine the optimal configuration.

- Only nine evaluations of the deposition model were required.
- The algorithm quickly converged despite the small data requirement.

Bayesian optimization successfully maximized the deposition rate in the model by 30%.

- Significant benefits in terms of throughput, quality, and cost reduction are expected.

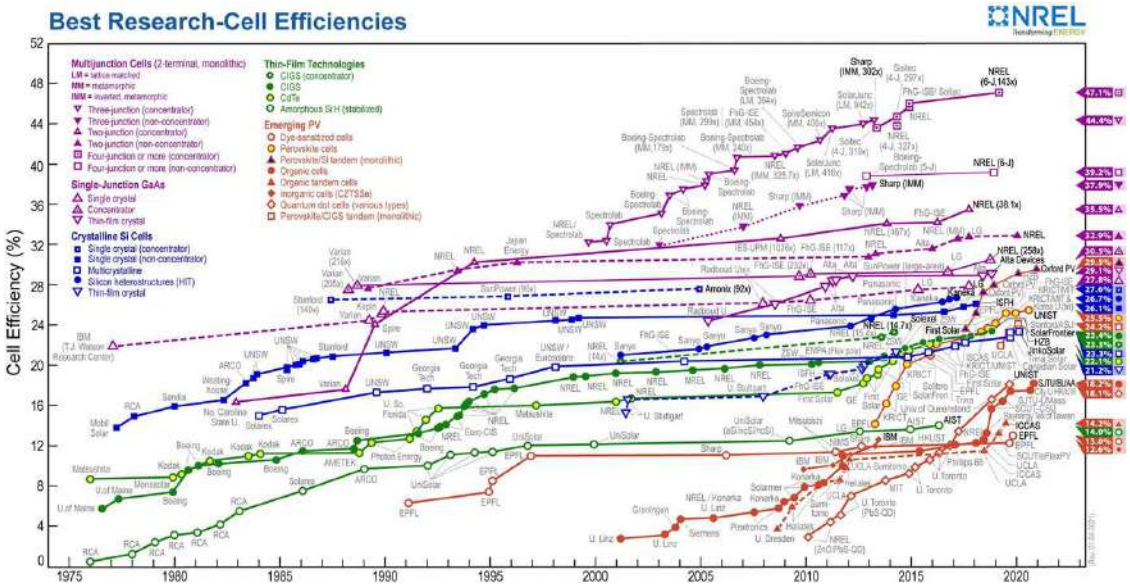
This methodology provides an automated, efficient way to optimize complex manufacturing processes.

- The optimization framework is flexible to other processes and objective functions.
- Bayesian optimization accelerates parameter optimization compared to conventional methods.

✓ **Advancing Thin-Film PV Efficiency and Manufacturing Semiconductor Materials and Process Innovation**
(Research Project)

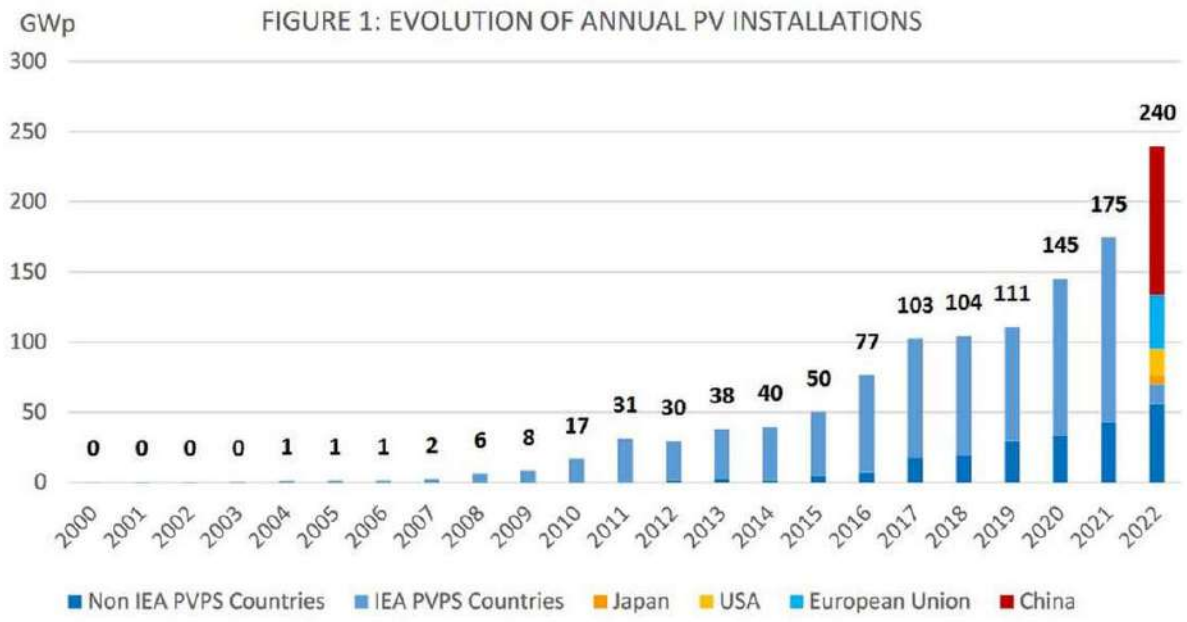
WHAT?

- Investigation into the potential of thin-film solar photovoltaic technologies to achieve over 30% cell efficiency and large-scale manufacturing by 2035.
- Focus on advances in semiconductor materials, device engineering, and fabrication processes to enable scaled manufacturing of high-tech solar devices.
- The 30% efficiency target is significant as it doubles the efficiency of current commercial panels and approaches the theoretical limits for single-junction solar cells.
- The global and temporal scope is worldwide, from the present until 2035, aligning with energy agencies' milestones for renewable energy cost reductions.



HOW? *(What data would be needed?)*

- Multidisciplinary systems modeling approach to combine engineering assessments with market trend extrapolation.
- Engineering-based models to estimate efficiency potential, considering quantum dot configurations, defect suppression, and bandgap optimizations.
- Economic modeling to forecast manufacturing expansion and cost learning curves under various policy scenarios.
- Techno-economic simulations to project adoption rates and assess sensitivity to R&D investments and process innovations.



RESULTS?

- Expected to provide probability distributions for thin-film solar cells surpassing 30% efficiency and production capacity forecasts by 2035.
- Anticipated impact on the solar energy landscape, with the potential to significantly alter solar PV capacity expansion and displace fossil fuel electricity generation.
- Implications for solar firms, policymakers, and research priorities in manufacturing, nanomaterials, photonics, and semiconductor synthesis routes.
- Contribution to global energy transition models and decarbonization trajectories, leveraging the power and energy density advantages of solar PV.

DOE PROJECTS

Includes DOE, JMP, Experimental Design, Excel Data Analysis.

✓ Optimizing Factors & Effects in Pour-Over Coffee Brewing with the Design of Experiment Approach

WHAT?

- Coffee is, and remains, one of the world's most popular beverages with an estimated 66% of Americans enjoying the drink daily.
- There is then a need to understand what makes good coffee to best understand how to leverage both the size of the market and the potential revenue one would enjoy by perfecting the process. It is also important to note the consumer benefits of optimizing the coffee brewing process.
- Thus, the aims of this experiment were to determine which factors and their levels in the brewing of pour-over coffee lead to both greater satisfaction from consumers and lie closest to an optimal pH value.

Table 1. Design Factors for Coffee Optimization Experiment

Factor	Description	Levels		Type
A	Grind Size	6 sec (-) (Courser)	14 sec (+) (Smoother)	Numeric
B	Water-to-Coffee Ratio	14?1 (-)	22?1 (+)	Numeric
C	Brew Water Temperature	195 °F (-)	205 °F (+)	Categorical
D	Coffee Bloom	No (-)	Yes (+)	Categorical
E	Brew Time	45 sec (-)	180 sec (+)	Numeric

Table 1. Depicts the design factors chosen to investigate the effects each factor presents in the brewing of pour-over coffee

HOW?

To provide structure to the process of rating consumer satisfaction to the various coffee treatments, a consumer coffee scoring tool was developed.

Table 4. Coffee Experiment Response Tool

1. Please rate the SMOOTHNESS of this coffee.				
Very Bitter (1)	Bitter (2)	Neither Smooth nor Bitter (3)	Smooth (4)	Very Smooth (5)
2. Please rate the INTENSITY or strength of the flavor.				
Very Weak (1)	Weak (3)	Just Right (5)	Strong (3)	Very Strong (1)
3. Please rate the AFTERTASTE of the coffee.				
Very Lingering (1)	Lingering (2)	Neither Clean nor Lingering (3)	Clean (4)	Very Clean (5)
4. This coffee's AROMA makes me want to pour a cup.				
Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)	Strong Agree (5)
5. Please rate the BODY or mouthfeel of the coffee.				
Very Thin (1)	Thin (3)	Neutral (5)	Heavy (3)	Very Heavy (1)
6. Please select your OVERALL level of satisfaction with the taste of this coffee.				
Highly Dissatisfied (1)	Dissatisfied (2)	Neutral (3)	Satisfied (4)	Highly Satisfied (5)

- Prior to brewing, several jars of coffee grounds were prepared according to the three grind times established by the grind size factor. These jars were then used to prepare 10g of grounds for each treatment.
- All containers that came in contact with treatment were washed thoroughly between trials.
- A scale was utilized to measure all water and coffee ground amounts throughout the experiment.
- Timers were utilized to ensure proper time measurements in brewing, grind time, and blooming.
- Each treatment was allowed to cool for 5 minutes prior to tasting for safety and optimality in testing conditions.
- Each pH measurement was taken after tasting to allow proper time for the treatment to cool.
- During tasting, each taste tester received an equal amount of the treatment and was allowed to score it privately.
- Following the test session, each taste tester adjusted their force ranking list (from 1-11, best-worst) for each day of testing.
- Following each trial, the data was recorded in the appropriate location both in the JMP design as well as a separate Excel spreadsheet.

While performing the experiment, data was collected both directly into the JMP design for future analysis and into an Excel spreadsheet.

Block 1															
		Forced Rank				AVG	STDEV		Survey Score				AVG	STDEV
Run Number		Daniyal	Varad	Jacob	Ryan				Daniyal	Varad	Jacob	Ryan		
1		7	11	6	5	7.25	2.629956		18	16	14	20	17	2.581989
2		9	7	5	2	5.75	2.986079		18	17	17	24	19	3.366502
3		1	2	3	6	3	2.160247		22	23	19	15	19.75	3.593976
4		11	5	10	11	9.25	2.872281		17	17	10	14	14.5	3.316625
5		4	1	9	3	4.25	3.40343		19	24	15	16	18.5	4.041452
6		10	3	2	1	4	4.082483		20	22	22	21	21.25	0.957427
7		8	4	4	9	6.25	2.629956		21	22	21	21	21.25	0.5
8		6	8	11	8	8.25	2.061553		20	18	15	20	18.25	2.362908
9		5	6	1	4	4	2.160247		19	22	22	19	20.5	1.732051
10		3	9	8	6	6.5	2.645751		20	18	20	14	18	2.828427
11		2	10	6	10	7	3.829708		23	17	16	12	17	4.546061
Block 2														
		Forced Rank				AVG	STDEV		Survey Score				AVG	STDEV
Run Number		Daniyal	Varad	Jacob	Ryan				Daniyal	Varad	Jacob	Ryan		
12		8	11	11	11	10.25	1.5		14	14	12	7	11.75	3.304038
13		7	6	3	3	4.75	2.061553		17	19	18	25	19.75	3.593976
14		9	1	10	5	6.25	4.112988		12	26	21	15	18.5	6.244998
15		4	8	5	4	5.25	1.892969		23	16	15	21	18.75	3.86221
16		10	10	1	2	5.75	4.924429		12	15	22	27	19	6.78233
17		2	2	2	7	3.25	2.5		22	26	21	14	20.75	4.99166
18		5	5	4	6	5	0.816497		19	20	17	15	17.75	2.217356
19		6	3	9	9	6.75	2.872281		18	23	14	11	16.5	5.196152
20		3	4	6	10	5.75	3.095696		22	22	15	8	16.75	6.70199
21		1	9	7	8	6.25	3.593976		26	15	15	14	17.5	5.686241
22		11	7	8	1	6.75	4.193249		12	18	19	28	19.25	6.601767

Figure 4. Experiment Data Table

RESULTS?

- Running an analysis considering both the average Forced Rank data and the standard deviation for Forced Rank data, a predicted optimal cup of coffee is found.
- The treatment is as follows: Grind the beans for 16 seconds, use the low-level Water-to-Coffee Ratio of 16:1, brew for three minutes at the high-level temperature of 205 degrees Fahrenheit, and make sure to let the coffee brew bloom for 30 seconds.
- This prediction not only provides a desirable coffee, but a coffee that is robust to the subjectivity of the consumers.

DESIGN, MANUFACTURING, PRODUCTION PROJECTS

Includes 3D CAD, AutoCAD, SolidWorks, CATIA, ANSYS (FEA)

✓ Sustainable Three-Stage Economical Air Filter to Trap Solid Pollutants

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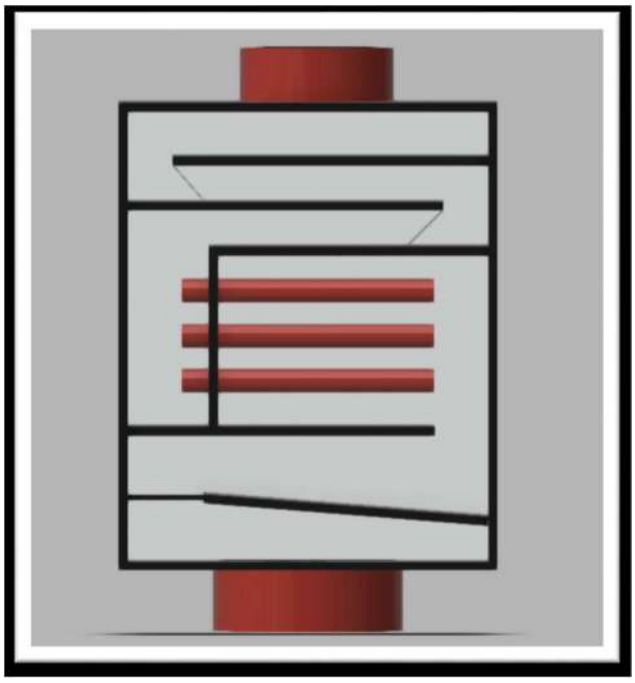
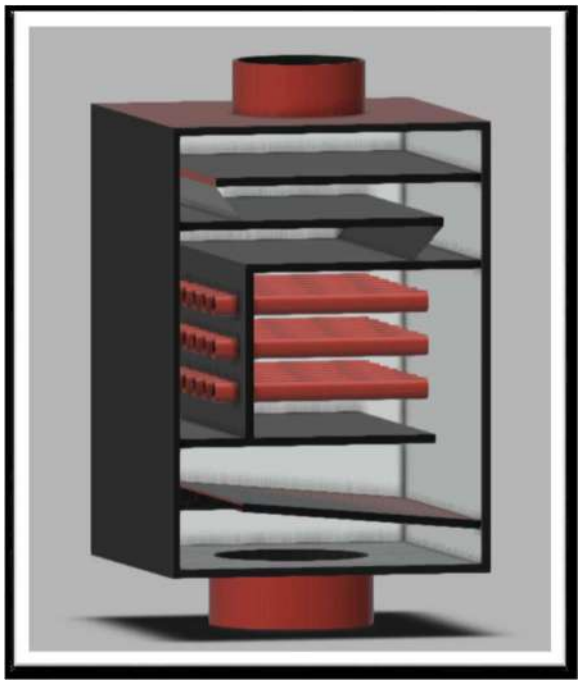
WHAT?

- Environmental pollution was recognized as one of the major problems of the modern world.
- After visiting small-scale industries such as foundry, jaggery industries, and textile industries we found that the small black color particles are present everywhere near these industries. These are the solid pollutants emitted from the chimneys of small-scale industries.
- Air pollution can cause long-term damage to people's nerves, brain, kidneys, liver, and other organs.
- Considering all these issues we can use air filtration technology in these industries to reduce the emission of solid pollutants and achieve a sustainable and healthy environment.

3D DESIGN OF AIR FILTER:





DESIGN FEATURES:

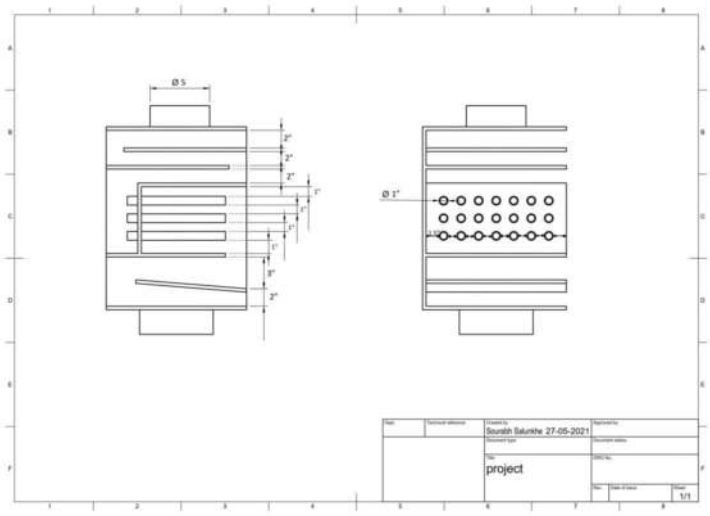
- We used Mild Steel because it has a melting point of 1350 to 1500 degrees Celsius.

- We provided a door on one side of the air filter for maintenance purposes to easily access over the replacement of the HEPA/ MANN filter and clean the filter from the inside.

- Packing material on joints and doors of the air filter to minimize air leakages.
- We used high-temperature packing material (Champion Sheet). A high-temperature packing sheet is used because in case the temperature of flue gas is high it should be sustained at that temperature for a longer period.

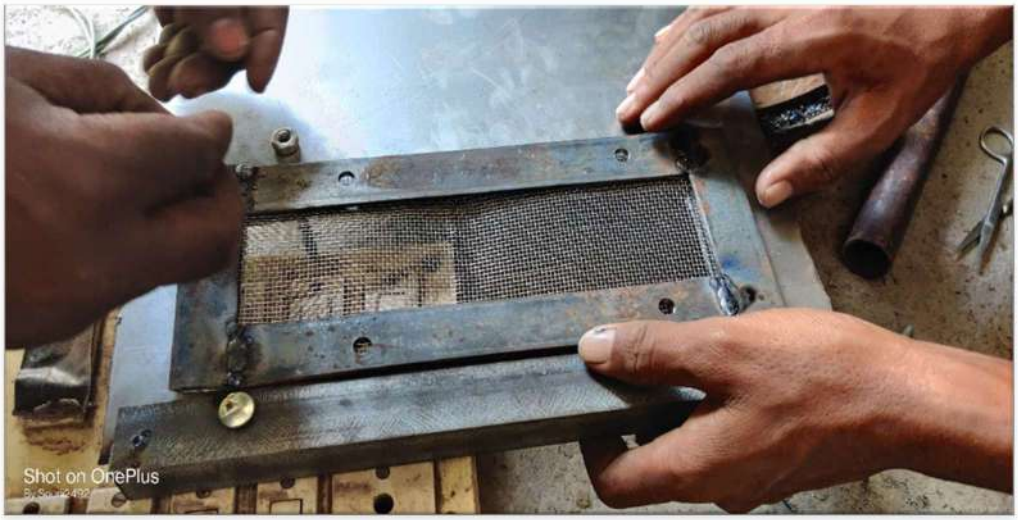
- Zinc chromate yellow primer coating is used. It is an odorless chemical compound primarily used as an industrial paint coating. The compound is a beneficial coating because it is an anti-corrosive and an anti-rust primer.

- HEPA filter is used which stands for high-efficiency particulate air. A HEPA filter is a type of mechanical air filter; it works by forcing air through a fine mesh that traps harmful particles such as pollen, pet dander, dust mites, and tobacco smoke
- Maximum continuous operating temperature 350°C, efficiency 99,99% at 0,3 µm.



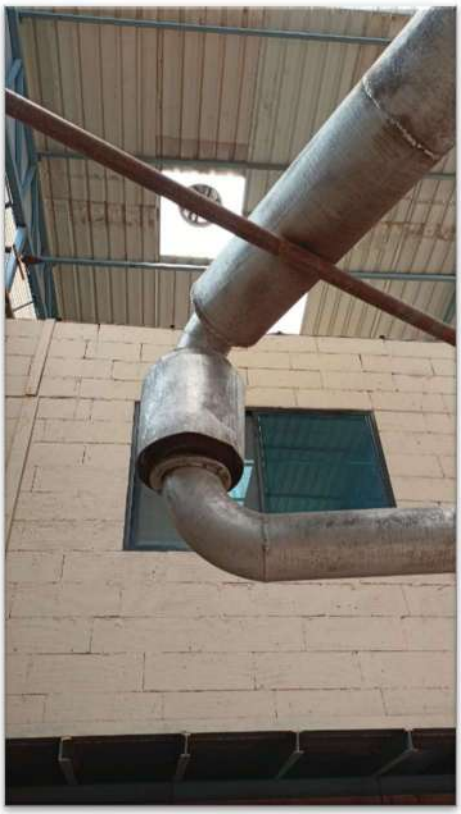
HOW?

- Firstly, we are done with all the dimensions on the M.S sheet and cut down all required sides.
- Then we formed a structure by using an L angle & welded all the sides on it.
- Thereafter we made the inlet portion by using a 5-inch M.S pipe mounted on an M.S sheet.
- Then we built the first chamber and placed the 1st HEPA/ MANN air Filter with a range of 10 microns.
- In the Second chamber we arranged 12 MS pipes with a diameter of 1inch each.
- In the third chamber, we have arranged HEPA air Filter with a range of 2.5 microns on its outlet.
- After that we set the outlet portion on it then we provide a door fully sealed to prevent air leakages by using a high-temperature packing sheet



RESULT?

- After doing an Experiment for 8 hours per day we trapped soot, dusty particles, and PM (particulate matter) which will expose us to air and harm the environment around us.
- The amount of collected solid pollutants on 1st day is 382.5 gm. On the 2nd day, the amount is 370.29 gm and on the 3rd day, the amount is 389.43 gm.
- The PM concentration on the 1st day was 20 mg/m3, on the 2nd day it was 19.3 mg/m3 and on the 3rd day it was 20.36 mg/m3. Thus, the average PM concentration is 19.88 mg/m3.



The Project was designed and analyzed and satisfies all the necessary conditions for an efficient, economical air filter. The different layers of filters used are quite simple and easily available materials (filtrates). The three-layer filtration makes an effective filtration process.

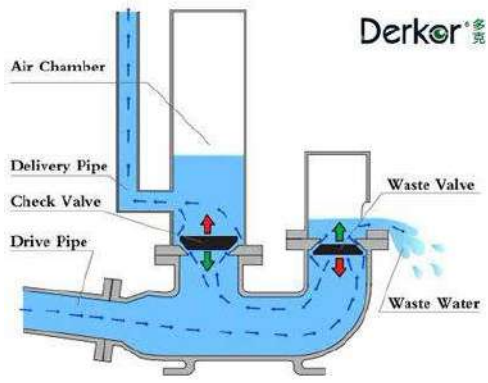
✓ Hydraulic Ram Pump for Rural Areas of India

WHAT?

- A hydraulic ram pump is a water pump powered by water with a height difference.
- In areas where natural flows exist with a height difference of the water over a small distance, hydraulic ram pumps can be used to transport water to higher grounds without using electricity or fuel in places without a constant electricity supply (Rural areas/Villages)
- The goal was to provide a sustainable solution for water pumping and transportation, especially in areas with natural water flows with a height difference.

HOW?

- To make this project, we conducted extensive research on the concept and design of hydraulic ram pumps.
- We studied the various components and materials that would be suitable for the construction of the pump.
- After considering the customer's requirements, we decided to use lightweight materials such as aluminum, PVC, and stainless steel, to keep the pump light, in weight and low in cost.
- To make the pump easy to use, we designed it to have a simple mechanism with only a few moving parts.
- The pump was designed with a closed-loop system that would prevent water from entering the pump's internal components, making it durable and long-lasting.



RESULT?

- The results of this project were successful. We were able to design and develop a hydraulic ram pump that met the customer's requirements.
- The pump was simple in mechanism, light in weight, low in cost, easy to use, and strong enough to withstand the demands of pumping water in rural areas and villages.
- The pump was assessed in different environments and performed well, proving to be an effective and sustainable solution for water pumping and transportation in areas without a constant electricity supply.

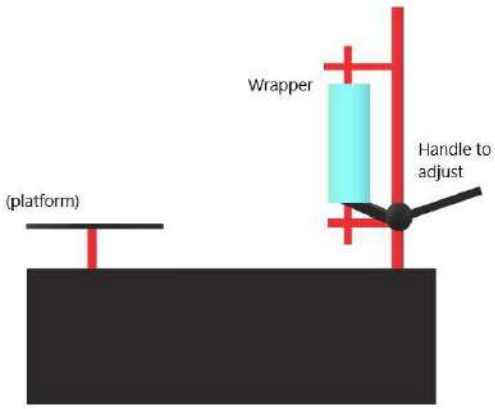
✓ Advanced Automatic Packaging Machine with PLC Control

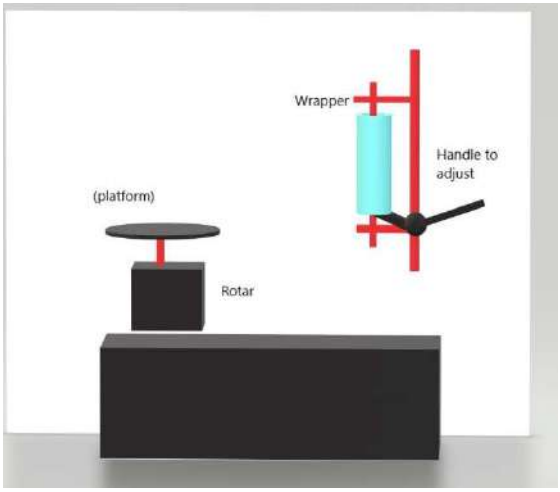
WHAT?

- The automatic packaging machine project was initiated to address the pressing needs in the packaging industry for improved efficiency, safety, and cost savings.
- The primary aim was to reduce the manual labor requirements in the packaging process and minimize the risk of injury to employees.
- The increasing demand for faster and more efficient packaging methods also contributed to the development of this project.

HOW?

- The project was executed with the guidance of a team of engineers and technicians who have experience in the packaging industry.
- Designed with SolidWorks and developed three prototypes of cutting-edge automatic packaging machine with a PLC system that is equipped to manage a wide range of goods, including fragile and heavy items.
- The machine is designed to ensure maximum load containment and consistency in wrapping, which leads to cost savings in the use of stretch film.





(Prototypes of the project for easy understanding of workers, cannot display the SolidWorks model because of the contract with the industry)

RESULTS?

- The automatic packaging machine was a highly efficient tool in the packaging process, as it can wrap pallets much faster than manual methods which reduced manual labor by 70%.
- The machine has also improved safety conditions in the workplace by reducing the risk of manual handling injuries. Moreover, the machine has enabled labor reallocation, freeing up employees to be more productive in other areas.
- The film cost savings was significant, as the consistency of wrapping and the ability to use less stretch film has resulted in 60% cost reductions and waste reduction by 75%
- In conclusion, the automatic packaging machine project has successfully addressed the challenges faced by the packaging industry and provided a highly efficient, safe, and cost-effective solution.
- The project was sold to the industry for 18,000Rs (INR) and it became a valuable tool for businesses in the packaging industry.

✓ Industrial Grade Brick-Making Machine for Small-Scale Industries

WHAT?

- For this Diploma major project, we wanted to develop something which is sustainable for small manufacturers.
- Small manufacturers used conventional processes which had drawbacks such as it required more time for production, a greater number of workers, and hence more space for production.
- The “Brick Making Machine” (Sold as “Paving Block Making Machine”) was made for small-scale industries to manufacture bricks and paving blocks at a lesser time with qualitative production in less effort.
- The goal was to make Brick Making Machine in a minimum cost so that it can be afforded to small-scale industries.
- The design of each part was also especially important, the design should be such that the machine can withstand continuous operations. We used CATIA V5-R2019 for part designing purposes.
- Knowledge of the Theory of Machines, Heat and Mass transfer, testing and measurements, and strength of the material was used while developing ‘Brick Making Machine’

HOW?

- While selecting the material we considered the following factors? Availability of Material, Suitability of Material for working conditions, and the cost of the material.
- After considering all the factors we decided to use Mild Steel as it is a type of steel alloy that contains a high amount of carbon.
- For the manufacturing process we used Lathe Machine, Grinding Machine, Drilling Machine, and Welding Machine, etc.
- The Brick making machine has four main parts: hopper, slider box, mold box, and pressing mechanism.
- The hopper is designed for easy pouring of raw material into the slider box and to prevent any residue from remaining in the hopper.
-
- The slider box collects the raw material from the hopper and transfers it to the mold box.
- The pressing mechanism, consisting of the mold box, long lever, and sliding mechanism, applies pressure to the raw material in the mold box to shape it.
- Pulling back the lever and pressing down again removes the paving block from the mold box.

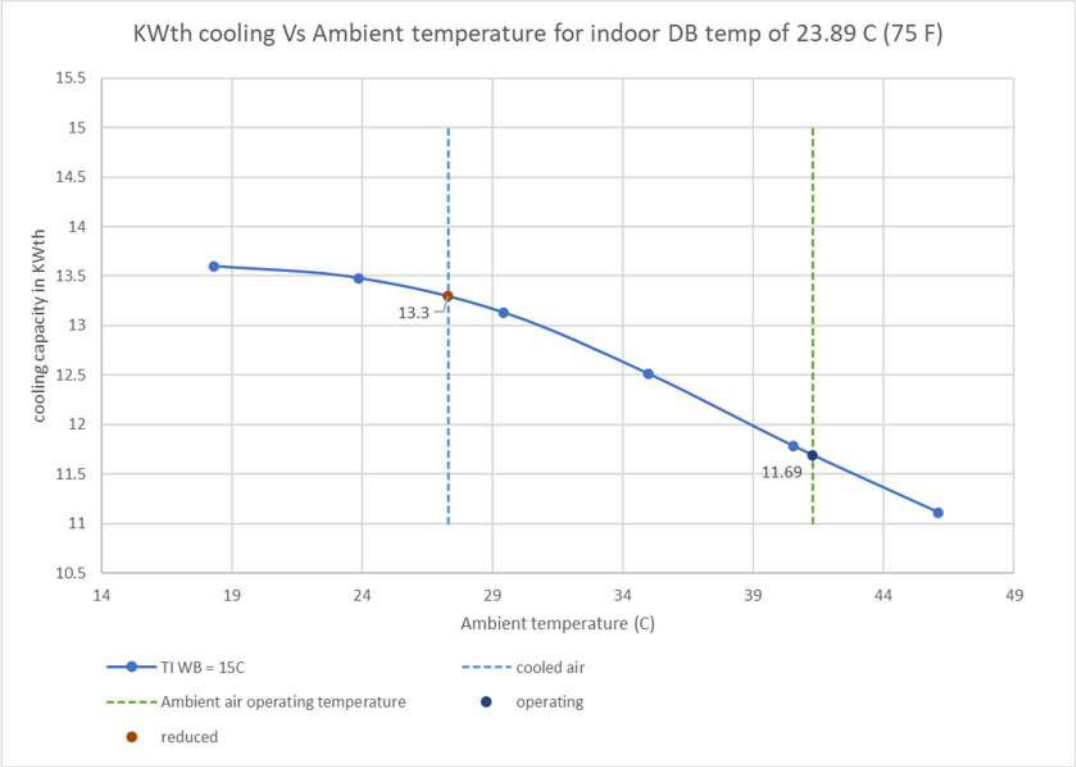
RESULTS?

- The main important thing is that the number of skilled workers required for the production of brick and paving blocks was less than the number of semiskilled and unskilled workers required to use this machine.
- In the conventional method six skilled workers were required the for production of brick and paving blocks whereas in this machine maximum of 2 workers, efforts required by the worker are also reduced.
- The time required for a single brick in the conventional method is about 15-18 minutes which is reduced to less than 5 minutes per brick.
- The initial investment of the machine is slightly higher than the conventional method, but this investment is a one-time investment, not paid monthly or yearly.
- Machine saves the monthly worker expenses at the same output. The only thing required is the small maintenance of the machine.
- The Brick Making Machine (Sold as: 'Paving Block Making Machine') was sold to the same industry for 11,540Rs (INR).

✓ Adding Mister to Vapor Compression System to Improve Cooling Capacity, [Project Calculation Link (Excel Sheet)]

WHAT?

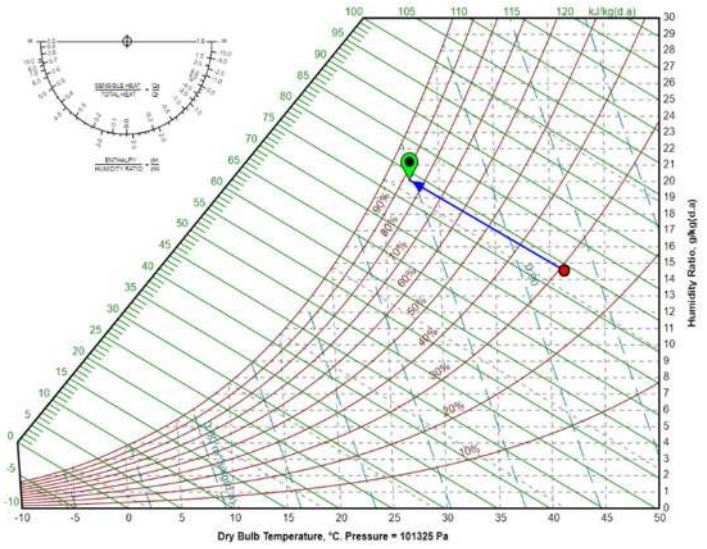
- The performance of the central AC system will decrease when the outdoor temperature increases.
- This is the case in Arizona where the ambient temperature increases up to 41 C with low humidity.
- The chart below shows how the AC cooling capacity gets derated when the outdoor temperature gets high which is the case of the weather in Arizona State during the summer season.

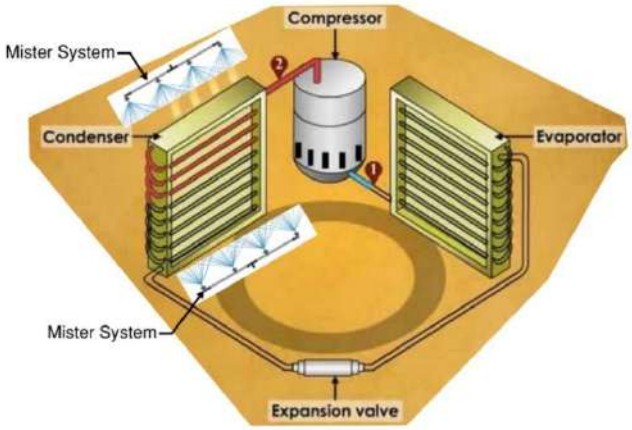


HOW?

- The table shows the operation pressure of R-410A at different Ambient temperatures.
- It is clear that the AC compressor needs to work harder and longer to achieve higher operating pressure which derates the cooling capacity of the system.
- Adding a mist system in front of the condenser will decrease the ambient temperature around the condenser and improve its performance.
- The psychrometric chart below shows how adding water to the air can reduce its temperature.

Temperature (°C)	Pressure (KPa)
18.33	1,275.53
21.11	1,385.85
23.89	1,503.06
26.67	1,620.27
32.22	1,889.16
35.00	2,033.95
37.78	2,178.74
40.56	2,337.32
43.33	2,509.69
46.11	2,682.06
48.89	2,868.22
51.67	3,061.27
54.44	3,268.12
57.22	3,481.85
60.00	3,702.49
62.78	3,936.91
65.56	4,185.12
68.33	4,447.12

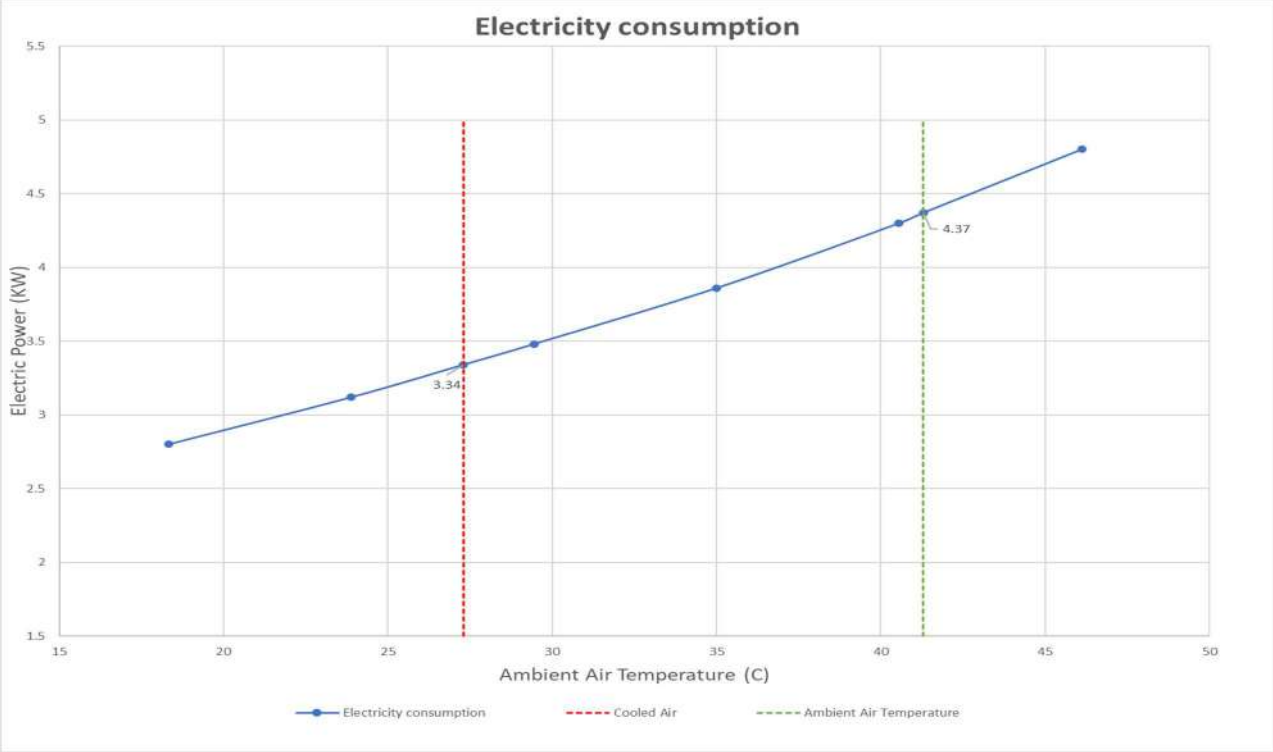




RESULTS?

- Based on United states Census there are 3,138,871 houses in Arizona as of July 1st, 2021.
- We considered only 70 % of that falls in our assumption of house size of 1900 SQFT and AC size of 4 Ton unit. We have 2,197,209.70 houses.
- The energy saving is 540,290,302 KWh per month which a cost saving of 69,319,245.77 $/month.

outdoor temp (C)	27.3	41.29	difference between using misters and not
indoor wet bulb temp (C)	15	15	
KWth	13.30	11.69	-1.61
ΔT	8.89	8.89	0.00
kW	3.34	4.37	1.02
Amps	12.74	17.40	4.66
HI PR (Kpa)	2232.64	3046.49	813.85
LO PR (Kpa)	932.90	1033.71	100.81
energy consumtion in 1 day (KWH)	26.72951351	34.92612613	8.196612613
energy consumtion in 1 month (KWH)	801.8854054	1047.783784	245.8983784
energy cost in 1 day ($)	3.429396584	4.481021982	1.051625398
energy cost in 1 month ($)	102.8818975	134.4306595	31.54876195



PROGRAMMING PROJECTS

Includes Python, MATLAB

✓ Image compression using Single Value Decomposition on MATLAB

WHAT?

The goal of this project is to perform image compression using singular value decomposition.

HOW?

Code starts

```
close all
clc
clear

% User can choose the image:
figure(1)
fprintf('Choose any image of any size:\n')
f = uigetfile;
```

Loading and displaying the image:

```
load(f)
imagesc (image)
axis off, colormap gray
title ('original grayscale image')

% Size of the image:
[M,N] = size(image);
```

Performing Single Value Decomposition (SVD)

```
X= double(image);
[U,S,V]=svd(X,"econ");
% econ for economy option to remove extra rows or columns of zeros
```

Making a semilog plot with log scaling in y axis

```
sigma = diag(S); %length (S)
ranks = 1:length(sigma);
figure(2)
semilogy(ranks, sigma/sigma(1))
xlabel('Rank r')
ylabel('Normalized singular values sigma/sigm(1)')
title ('Semilog plot')
grid
```

Rank of r0 when σr0 /σ1 = 0,01

```
r0=find(sigma/sigma(1)<0.01,1);
fprintf('\nWe get sigmar0/sigma1 = 0.01 at rank r0 = %d\n', r0)
% r0 = rank at which the singular value falls below 0.01
```

Compression ratio for rank r0 approximation

```
c= M*N/(r0*M + r0*N + r0);
% c= a vector of size 1x5 containing compression ratio for rank-r0 approximations
fprintf('\nCompression ratio for %d rank r0 approximation= %f\n', r0, c);
```

Building and displaying rank-2, rank-10, rank-50, rank-100 approximation of the original image

```
for r= [2 10 50 100 r0]
    Xapprox = U(:,1:r)*S(1:r, 1:r)*V(:,1:r)';
    figure()
    imagesc (Xapprox)
    axis off
    colormap gray
    title(sprintf('Rank %d approximation', r))
    c= M*N/(r*M + r*N + r);
    fprintf('Compression ratio for rank %d approximation: %f\n',r,c)
end
```

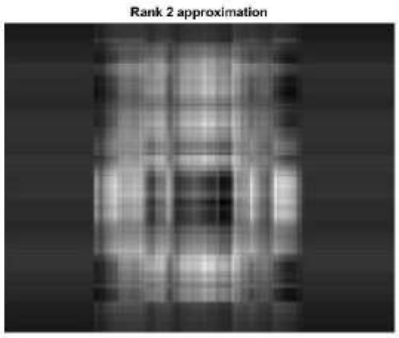
Commenting on their visual quality

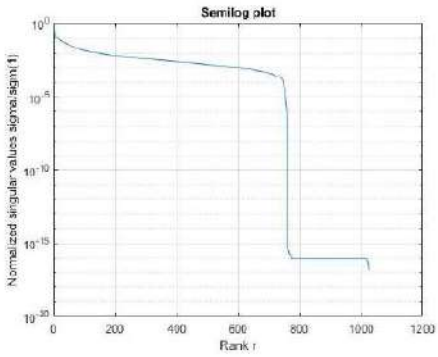
```
fprintf('\nComparing their visual quality:\n')
fprintf('For rank 2 the visual quality is blurry. Not able to identify the image because of pixelated quality.\n')
fprintf('For rank 10 the image quality is slightly better and the outline of the image is visible.\n')
fprintf('For rank 50 the image quality is far more better than previous one and the image is visible but is not very clear.\n')
fprintf('For rank 100 the image is clear and visible.\n')

% As we can not assume on which rank r0 sigmar0/sigma1 will be 0.01, we compare the value to rank 100 %
% if else function is usedto determine the visual quality %
if r0>100
fprintf('For rank %d the visual quality of the image is  more clear than rank 100.\n', r0)
else
    fprintf ('For rank %d the visual quality of the image is lower than the visual quality of the image of rank 100.\n',r0)
end
end
```

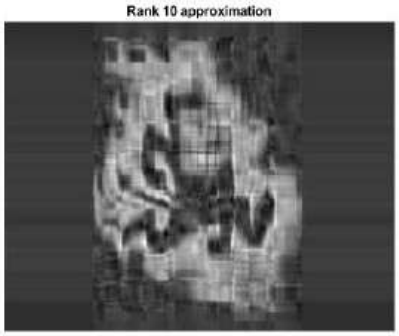
RESULTS?

```
Choose any image of any size:

We get sigmar0/sigma1 = 0.01 at rank r0 = 149

Compression ratio for 149 rank r0 approximation= 3.925079
Compression ratio for rank 2 approximation: 292.418410
Compression ratio for rank 10 approximation: 58.483682
Compression ratio for rank 50 approximation: 11.696736
Compression ratio for rank 100 approximation: 5.848368
Compression ratio for rank 149 approximation: 3.925079

Comparing their visual quality:
For rank 2 the visual quality is blurry. Not able to identify the image because of pixelated quality.
For rank 10 the image quality is slightly better and the outline of the image is visible.
For rank 50 the image quality is far more better than previous one and the image is visible but is not very clear.
For rank 100 the image is clear and visible.
For rank 149 the visual quality of the image is  more clear than rank 100.

ans =

   149
```

Image Compression:







✓ **Password Generator Using Python**

WHAT?

- In today's digital age, having a strong and secure password is more important than ever. However, remembering a strong and unique password for each of your online accounts can be a challenge.
- That is where a password generator comes in handy. This project aims to provide a simple and efficient solution to generate random and secure passwords that can be used for various online accounts.

HOW?

- The ‘import random’ and ‘import string’ statements import the necessary modules required for the password generator.
- The ‘password_generator’ function takes an ‘input length’ and generates a random password of the desired length.
- The ‘chars’ variable holds a combination of ASCII letters, digits, and punctuation characters.
- The ‘return’ statement uses the ‘join’ function to concatenate the randomly generated characters from the ‘chars’ variable to form a password.
- The ‘length’ variable is initialized by taking the input from the user.
- The generated password is printed using the ‘print’ function.

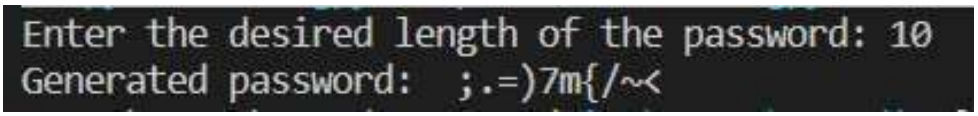
password generator.py

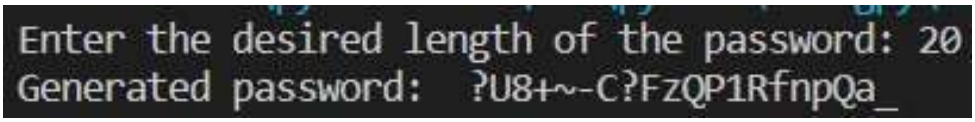
C: > Users > varad > password generator.py > ...

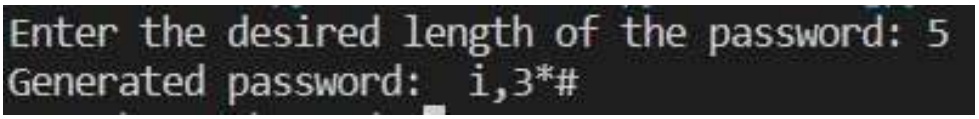
```
1  import random
2  import string
3
4  def password_generator(length):
5      chars = string.ascii_letters + string.digits + string.punctuation
6      return ''.join(random.choice(chars) for i in range(length))
7
8  length = int(input("Enter the desired length of the password: "))
9  print("Generated password: ", password_generator(length))
10
```

RESULT?

- The password generator is a simple and efficient solution for generating random and secure passwords.
- It can generate passwords of varying lengths and complexity, depending on the input provided by the user.

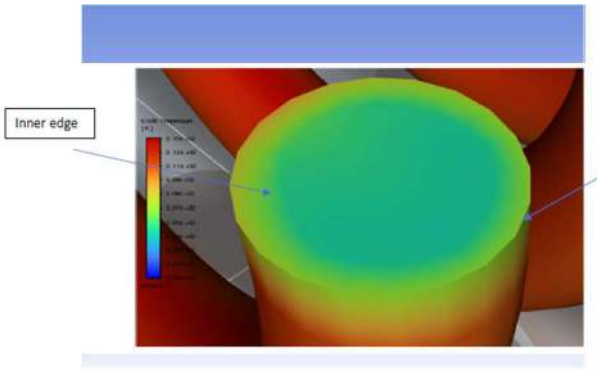




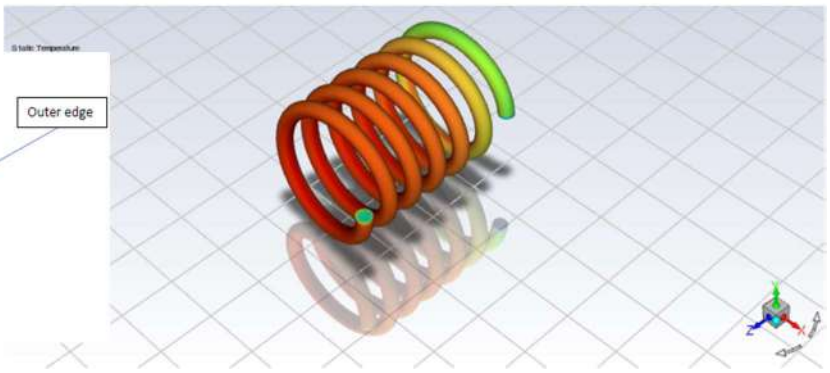


- The combination of letters, digits, and punctuation characters ensures that the generated passwords are strong and secure. The code can be easily modified to include additional characters or constraints, such as excluding similar characters or avoiding certain sequences.

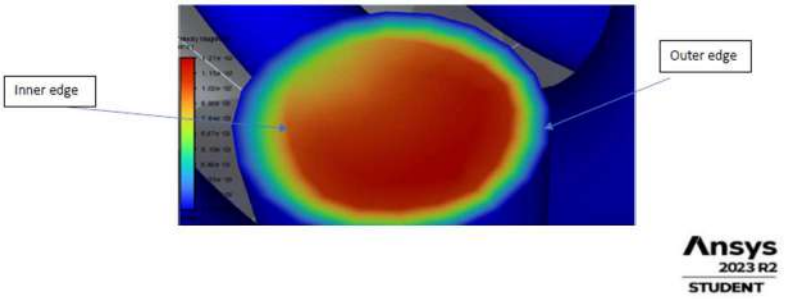
✓ Applied Computational Fluid Dynamics, ANSYS analysis (FEA):

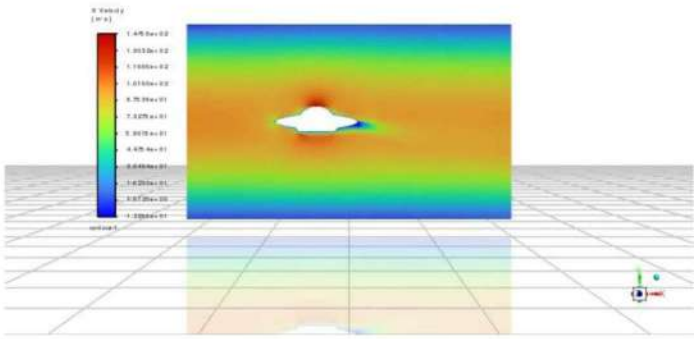


3D Helical Pipe



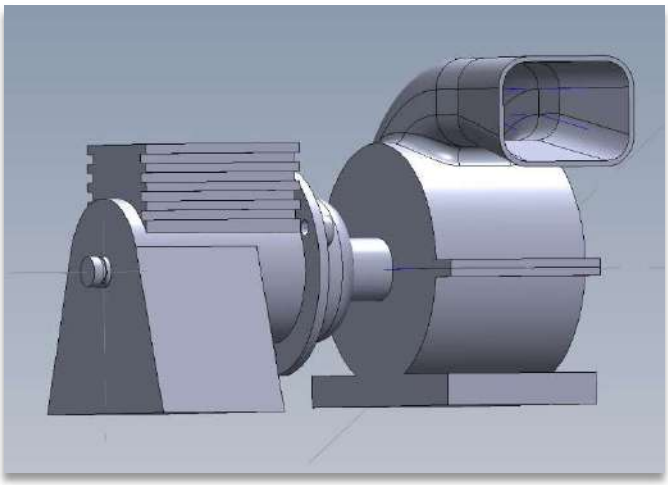
Flow with heated wall (water)l

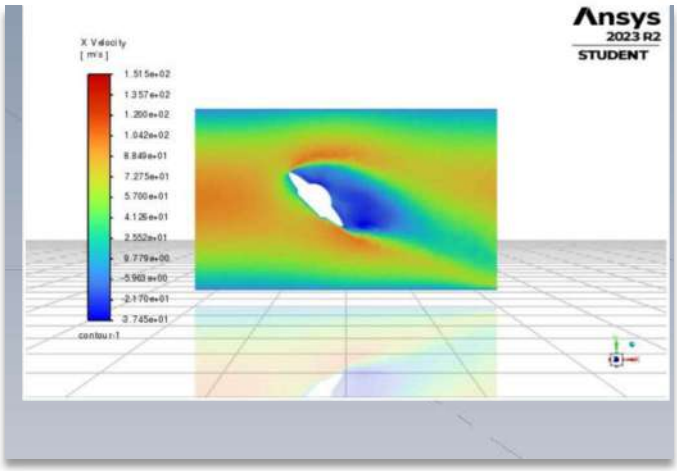


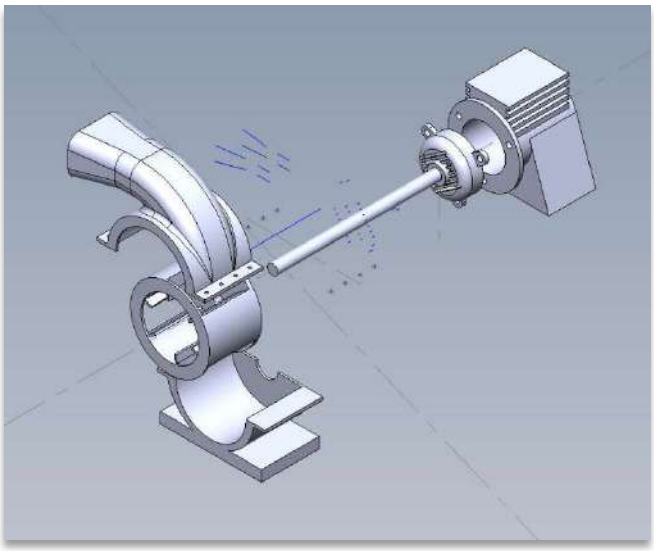


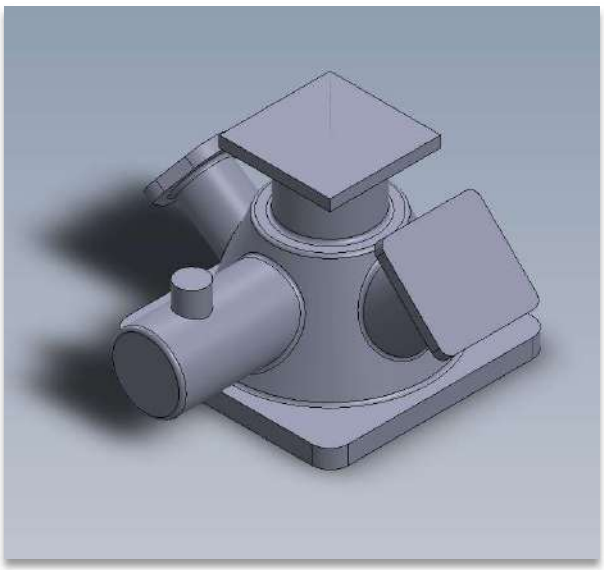
Tests on aerodynamics of a 3D Flying Saucer Contour plots of x-velocity on plane of symmetry

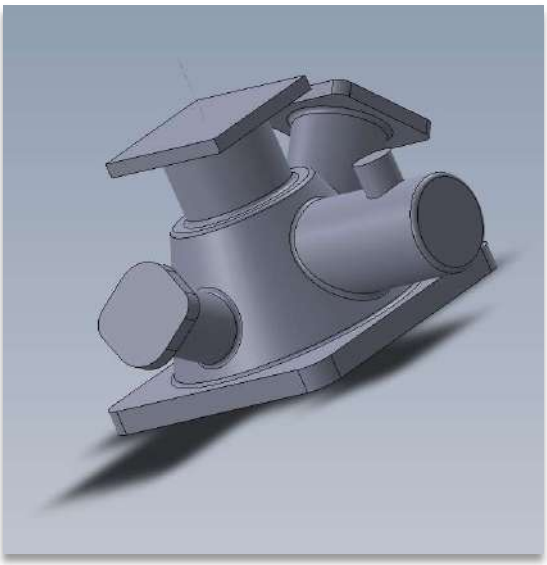
SolidWorks 3D modeling and assemblies

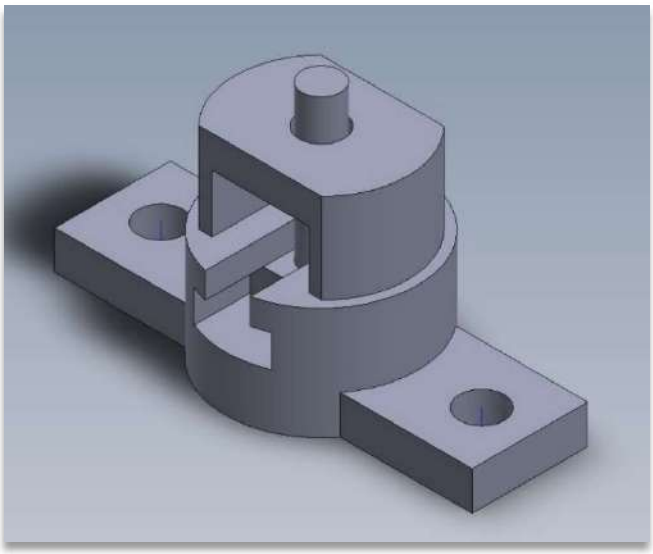


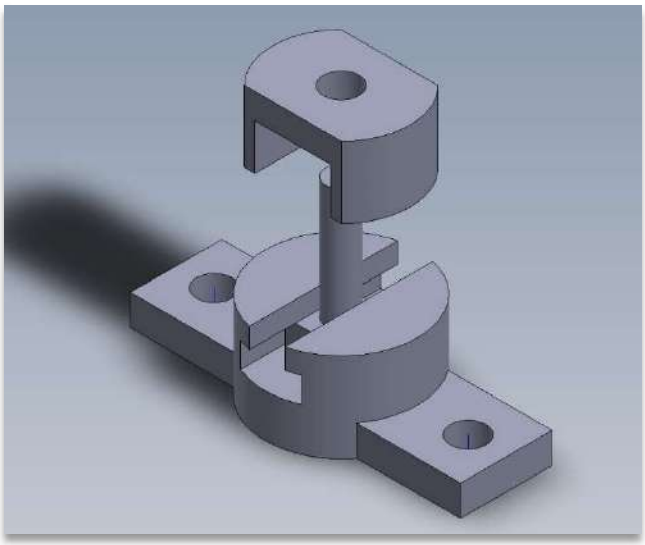


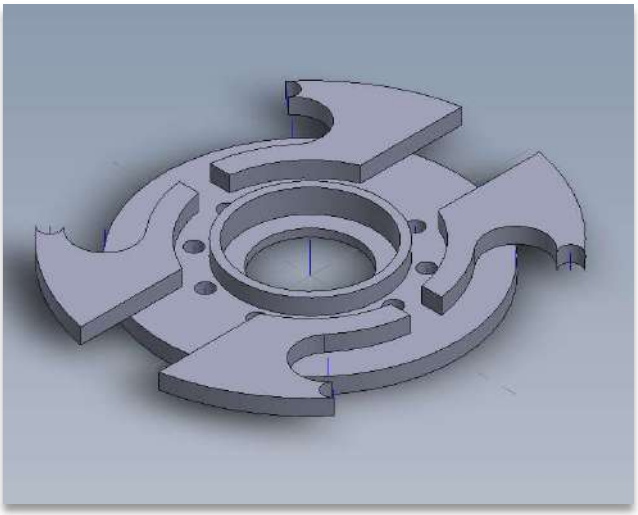


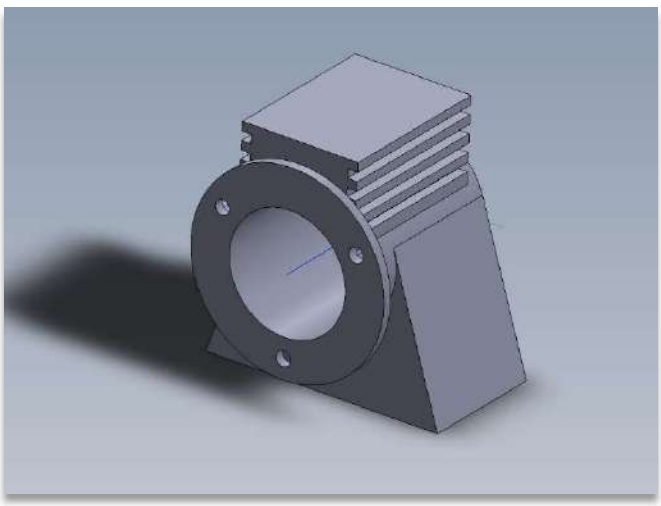


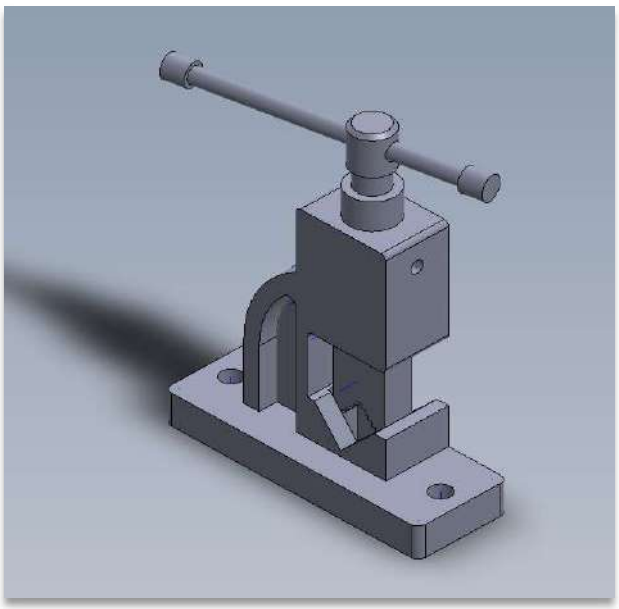


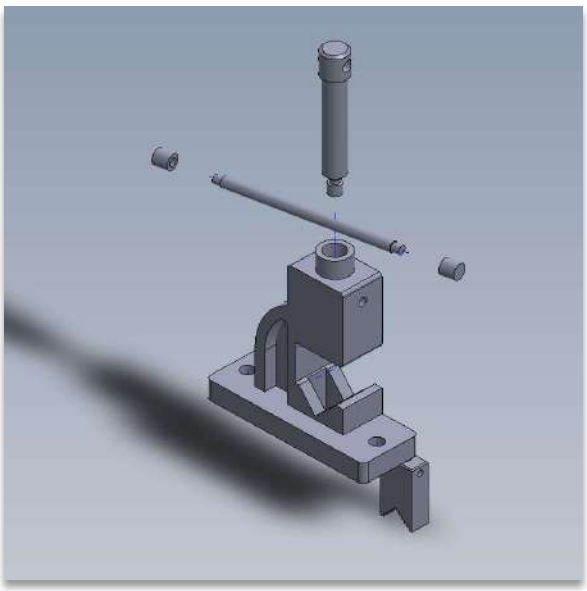


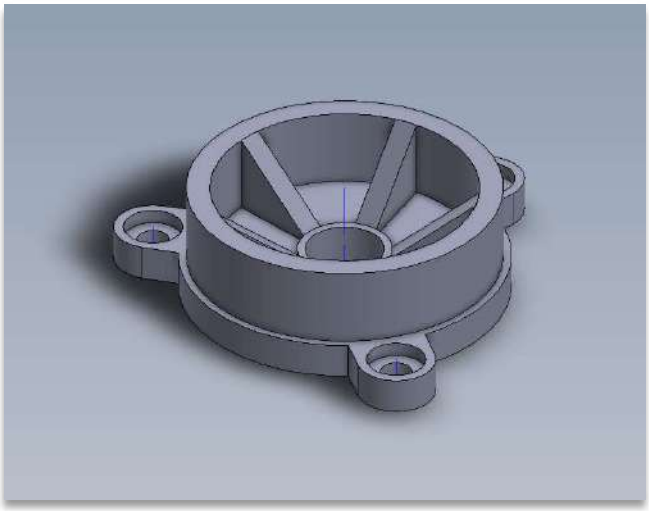


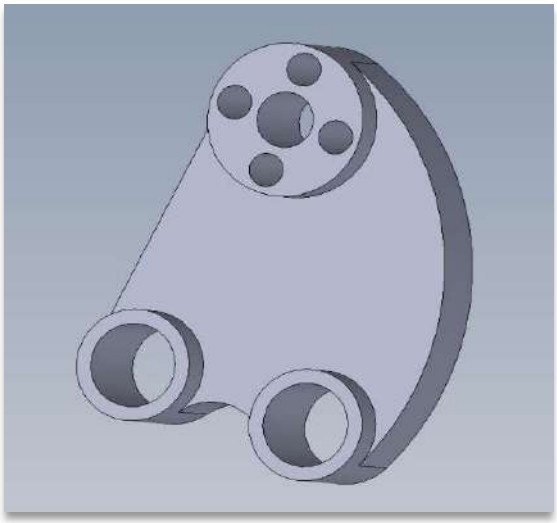


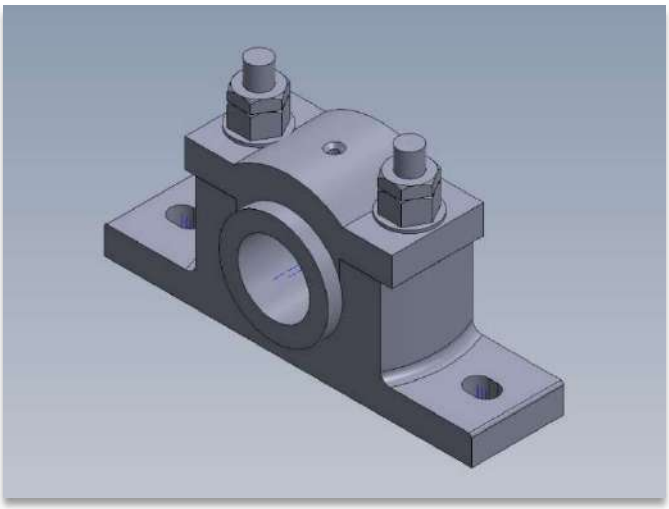


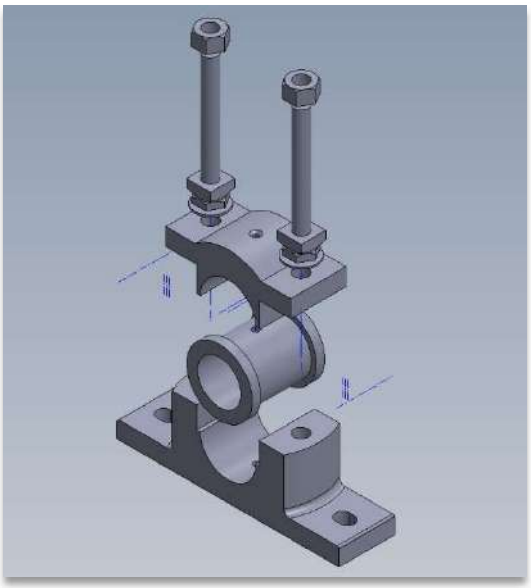


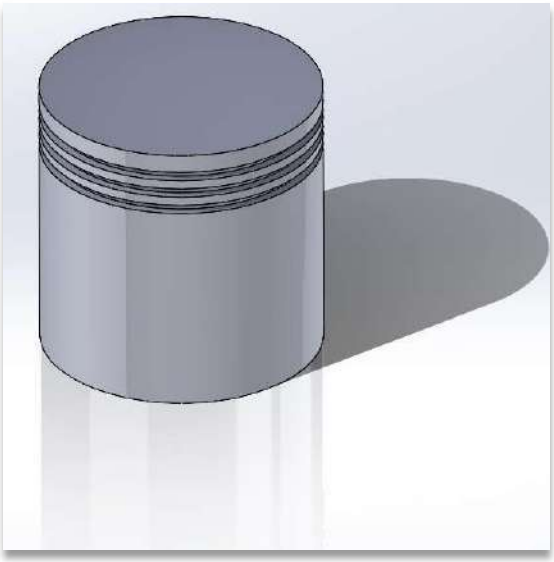


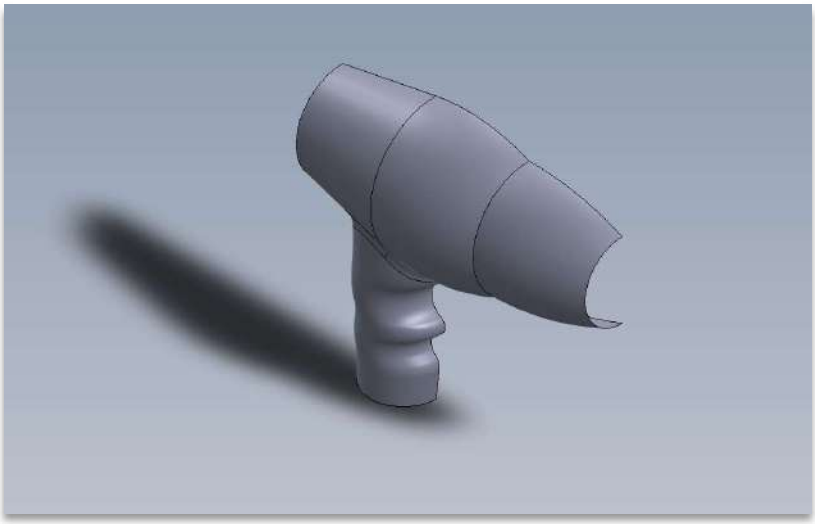




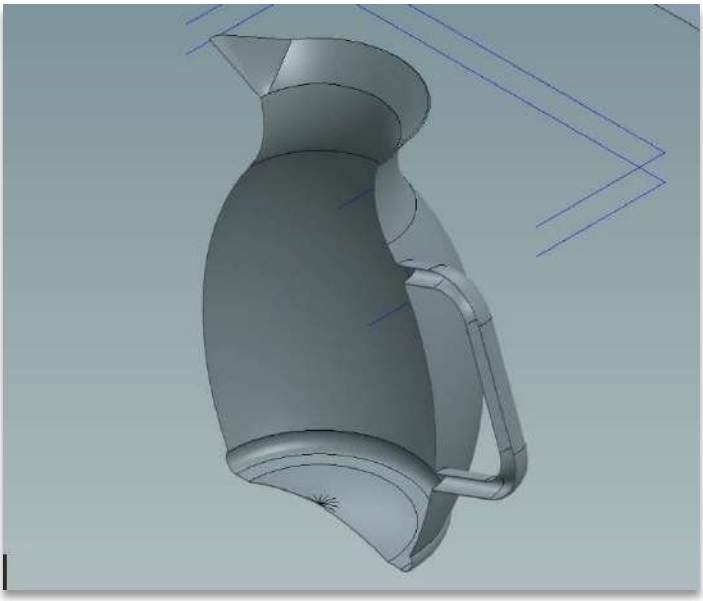




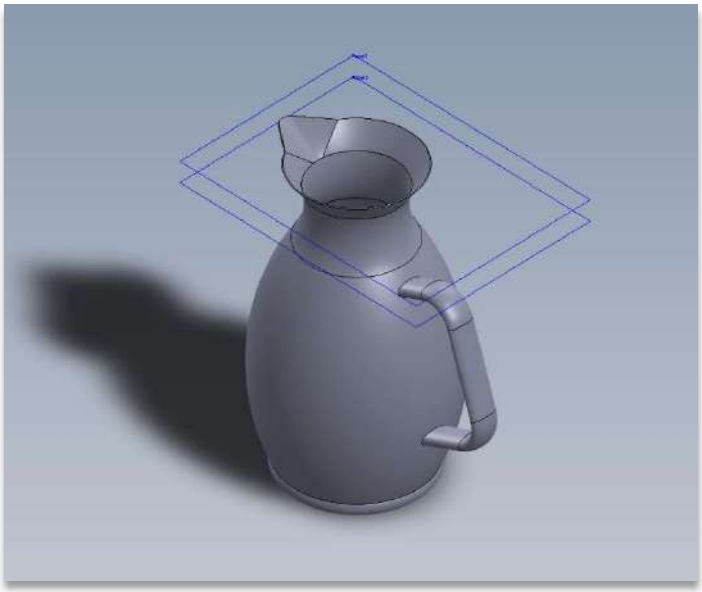




(Made with Surface Modelling)



(Made with Surface Modelling)



(Made with Surface Modelling)

✓ Catia 3D modelling (complex parts)