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Engineering Portfolio

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1 Introduction

With a Master's degree in Mechanical Engineering from the University of Texas at Arlington, I have been shaping my career around Mechanical design of parts and components through my academic ventures and professional experiences. **This portfolio is designed to supplement my resume by presenting my previous experience, skills and academic projects in a brief yet comprehensive document appreciable by both a layman or an expert in engineering.** I have gained invaluable skills, knowledge and contacts through the years of my experience. During my time at The University of Texas at Arlington I have capitalized on several opportunities, expanding my skills and evolving a novel approach to solving problems and accomplishing engineering tasks. Through internships and academic projects, I have gained a broad outlook on Mechanical Design of components such as beams, shafts, pumps, compressors, engines etc.

2 About Me

My fascination for Mechanical design stems from my personal penchant for engineering things ever since I was a kid. Curious by nature, I used to dismantle toys and old printers, read scientific magazines, engage in school projects and never missed an opportunity to visit my uncle's oil drilling rigs where I learned a lot about compressors, pumps, engines and crude oil production. Accomplishing projects like Hybrid Powertrain design and V-Belt Design gave me a holistic outlook regarding mathematical modeling, structural and thermal analysis of components and assemblies being under various conditions and loads. Ultimately I hope to make a career as an engineer in the design engineering field.

Taking courses such as Finite Element Methods, Engineering Analysis and Computational Fluid Dynamics has made me adept at the formulation and analysis of problems such as stress analysis of parts, design of components with DFMEA practices to ensure reliable operation. In my free time, I like to stay up late and observe stars and constellations with my telescope, and it gives me immense pleasure locating planets in the night sky and relish their beauty through the lenses.

3 Professional Experience

3.1 Kruhet Enterprises

Kruhet Enterprises is a small scale manufacturing firm in Gandhinagar, India. They receive contracts from third parties that might be from various sectors such as automotive manufacturers, pump manufacturers etc. and manufacture components as desired by their clients in bulk. This enables them to be involved in several industries and use their expertise to manufacture parts on CNC machines while supplementing their demand with other rudimentary parts such as pump casings, compressor casings, piping blocks, drilling rig couplings etc. **As a Mechanical Design Engineer, my primary task was to design components within the required structural and thermal tolerances and then model them using CAD software (PTC Creo).**

One major challenge that I undertook and accomplished was when we could not manufacture a certain part with conventional CNC machines. Normally, the supervisor would return the part for redesigning and after a couple phases of redesigning if we still could not manufacture it, we would return the advance payment and inform the client that we were unable to manufacture the certain part. Due to my acquaintance with 3-D printing, I was sure that the part could have been 3-D printed with ease, but since the technology was fairly nascent, my superiors were hesitant about it. I eventually did convince them and managed to outsource the manufacturing of that part to a 3-D printing firm in my city. It ended up being more expensive than we had planned for but we gained a new recurring customer. In addition to these tasks I would also occasionally act as a liaison between the company and its clients, frequently meeting with them to discuss about their part requirements, which designs and processes would be the most efficient and economical while accommodating specifications of a part in design that might be required for compatibility later.

Figure 1: Pulley with a coupler housing

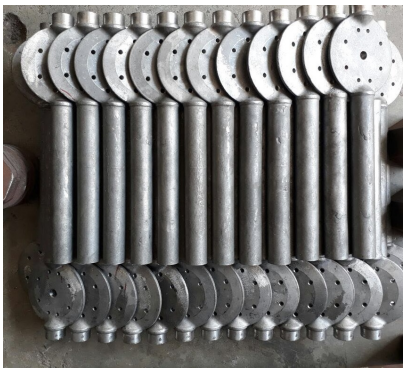

Figure 2: Mass produced butterfly valves

Figure 3: Shafts designed and manufactured

3.2 Oil and Natural Gas Corporation Ltd.

ONGC (Oil and Natural Gas Corporation Ltd.) is the largest Oil and Gas company in India and produces about 70% of the total crude oil extraction in the country, they do not however refine the petroleum products. ONGC is a Fortune global 500 company, with worldwide operations and divisions such as geophysical exploration, drilling, cementing, production and maintenance. During my time at ONGC, I was introduced to a well oiled and rigorous company structure and hierarchy, where I also learned the importance of communication, team work and collaboration of various departments.

I interned at two different facilities, the maintenance workshop and the cementing department. I also visited several facilities to gain a comprehensive outlook of oil and byproduct processing such as Gas Gathering Stations, Waste Water Treatment Plants, Central Tank Farms etc. At the workshop job floor I learned **operating heavy machinery such as forklifts, compressors, pressure regulators and cement pumps while also understand their maintenance procedures.** For an in depth exposure to engines and their maintenance, we carried out a rigorous scheduled regimen of disassembling a Cummins N-855-F engine that was used to drive a pressure regulator for oil well rigs and then reassembling it. With the cementing division I **assisted the control room manager in dispatching vehicles and handling logistics. I also computed volumetric calculations** from probe data for the prediction of required curing cement and chemical additives.

4 Projects

4.1 Experimental Hybrid Power-Train and Simulink (MATLAB) Model

To investigate the performance factors, efficiency and the overall general viability of Engine-Electric Hybrid vehicles I lobbied for my university to fund a major project that **included the complete process of designing, CAD modeling, structural and thermal analyses, procuring and manufacturing parts, assembly and test benchmarking of an experimental hybrid powertrain testing rig.** This project required holistic development and execution of multidisciplinary skills and their application in a timely manner. I lead a team of four students including me, scheduled and parametrized tasks and kept a firm hold on the progress of the team which was invaluable leading experience.

I designed and manufactured a structural frame to mount all the components with required structural integrity for supporting the loads and the vibrations. Several parts and components such as the engine, the motor and the electromagnetic clutches were procured from vendors and assembled on the frame. On several occasions we required help from other departments, such as designing the control system of the electromagnetic clutch that would engage the electric motor when the engine hits a set value of RPM and I learn the value and importance of collaboration in this endeavor. I also developed a MATLAB Simulink model and programmed it to simulate, with some constraints to predict and validate some of the performance factors. Once the rig was furnished, we performed several test runs with different loads and RPM settings when the electric motor would take over to see the effect on the overall efficiency.

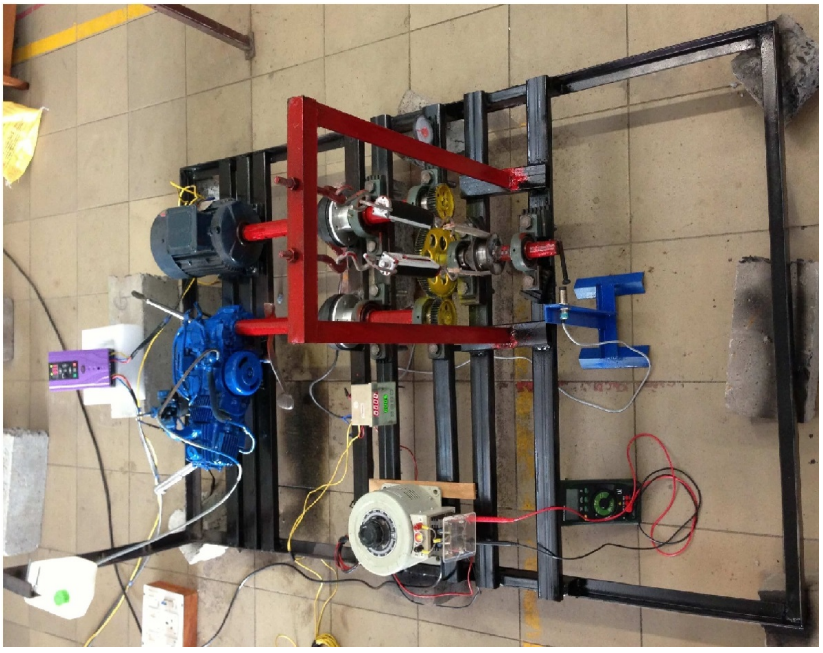

Figure 4: Engine-Electric experimental Hybrid Powertrain rig

4.2 HVAC system optimization and energy conservation in an office space

HVAC (Heating Ventilation and Air Conditioning) systems are ubiquitous in almost all buildings, and are also a major energy sink for any given building. It makes sense that the efficiency of such systems can have a lasting impact on energy bills, for years. Its optimization, especially in larger buildings with numerous equipment and personnel becomes crucial not just to reduce the cost, but also help move towards a greener environment. For this project, I **determined the heat loads in an office space, computed calculations and analyzed the parameters that can be varied to improve the efficiency of the HVAC system.**The primary heat loads include heat transfer through walls and roof which may change depending on their orientation direction, solar radiation through several windows, heat dissipated by equipment such as desktop computers, printers and finally through the average number of people present in the building at any given time.

Other factors, such as the climate and weather of the location, type of the HVAC system, placement of vents and exhaust can also have a considerable effect on the efficiency of the system, but to accommodate feasibility some assumptions were made. I calculated the total thermal loads including sensible and latent heat loads, while also considering ambient radiation heating by lights present. Another component that needs to be factored in is the heat gain through infiltration, i.e. the heat transfer representing leakage of air etc. and to simplify those calculations I employed a technique called the crack length method. Computing everything, I determined the HVAC to be over capacity by 20kW. I also **suggested some changes to vent placements, window panes, insulating certain parts of walls and reflective coating on the outside to increase the efficiency.**

No	Load Components	Sensible Heat (W)	Latent Heat (W)
1	Heat Transfer through walls	71300.84	-
2	Heat Transfer through windows	8816.97	-
3	Solar Radiation through Windows	66127.28	-
4	Heat Transfer through roof	42564.38	-
5	Human Heat Load	11077	9196
6	Light Radiation Heat load	10600	-
7	Equipment	4500	-
8	Infiltration	13506.53	20260.02
9	Miscellaneous	2000	-
		230493	29456.02
	TOTAL HEAT LOADS (W)		259949.02
	Cooling load Available (HVAC)		279840

Figure 5: Heat loads in the selected office space

4.3 V-Belt Design and MATLAB Program.

This was a design project, a new and challenging task for me during my undergraduate

studies. The aim was to **design a power transmission V-belt, including the shaft and pulley design,** and creating a MATLAB code to do the same, which could readily take a range of inputs to make calculations and suggest suitable bearings and V-belts from a specific manufacturer catalog. I learned several aspects of design, making calculations by hand gave me a new perspective on designing calculations of shafts and invaluable insight into mathematical modeling, their subsequent coding and failure analysis methods. I created a **comprehensive MATLAB program (around 1600 lines)** which could take certain inputs from the user and provide the user with simple, manufacturing oriented data that could directly be employed into a machine or be used to procure parts that could be assembled. The chosen V-belt was then ordered to a local manufacturer for manufacturing.

Figure 6: Manufacturing V-belts

Figure 7: Heat Treatment of V-Belts

4.4 Analysis of 2-D inhomogeneous Heat equation with different source terms using Alternate Direction Implicit Method

The heat equation represents one of the fundamental physical phenomenon, and to cover a holistic thermo-fluidic design perspective, an effective way solving it becomes critical. The basic 2-D equation might look rudimentary at a superficial glance and can be solved exactly using traditional PDE (Partial Differential Equation) solving methods, but it is a far cry away from the depiction of the real world problem. Approaching the real world problem requires mathematical modeling of several terms that account for the physical phenomenon that occur along with heat transfer which can not only make the equation fairly complicated but also the solution. It becomes nearly impossible or impractical to then solve this equation exactly. Hence an unconventional method of solving the problem is generally applied.

I approached this problem by approximating the PDE with a second order accurate finite difference method on a uniform grid. These methods are very suitable for thermo-fluidic problems and can be effectively and efficiently used to obtain solutions of such equations. To make the computation more economical I employed the (ADI) Alternate Direction Implicit Method. **Using the ADI method essentially reduces the problem to two phases depicting two one dimensional sweeps and yields a Tridiagonal Matrix that can**

be easily solved using a Thomas algorithm designed for a tridiagonal matrix in MATLAB. The problem was solved at different time steps but for brevity, solutions and results for the steady state with a source term xy can be seen below with corresponding software verification using FreeFEM++ CS.

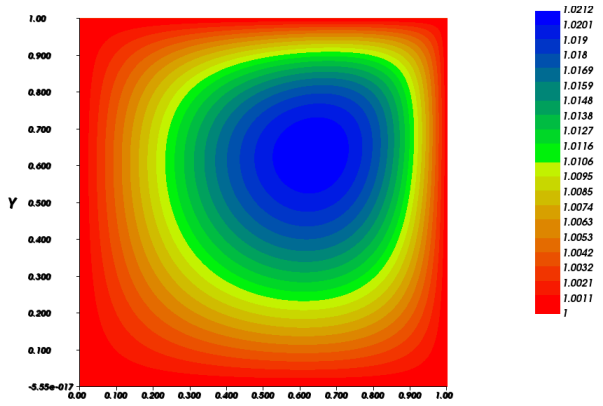

Figure 8: FreeFEM++ Results

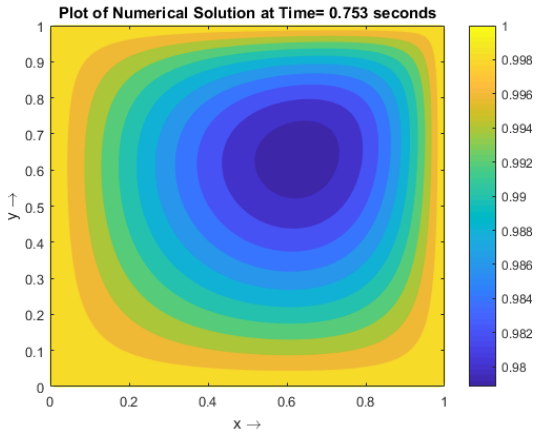

Figure 9: MATLAB solution

4.5 Thermal Analysis of a Thin Quad Flat Package (TQFP) and Thin Small Outline Package (TSOP)

Mathematical modeling and theoretical analysis are only the fundamentals that are required for the basis of Thermo-fluidic design and understanding the underlying concepts. Expanding my expertise to design of practical application components both large scale and small such as electronic packages, PCBs (Printed Circuit Boards), Engines, Pumps etc. is essential. For that, I **accomplished a two phased project that dealt with the CAD design and thermal analysis of convection cooled TQFP (Thin Quad Flat Package) and a TSOP (Thin Small Outline Package) in ANSYS Spaceclaim and Workbench.** This was a very good practice in approximating real world situation that develop while designing parts and assemblies.

The CAD models were successfully designed in ANSYS Spaceclaim; TQFP with components such as leads (exposed and unexposed), gold contacts, die, PCB, mold and die attach and the TSOP with die, die Attach, leadframe pad, gold wires, expoxy mold, leads (exposed and unexposed) with appropriate materials assigned. The thermal curves and temperatures for the die of the TQFP and the whole TSOP assembly can be seen below.

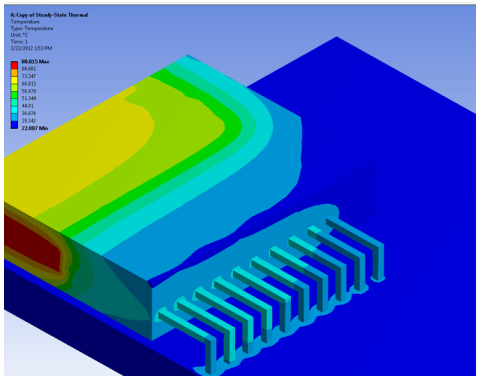

Figure 10: TSOP termperature distribution

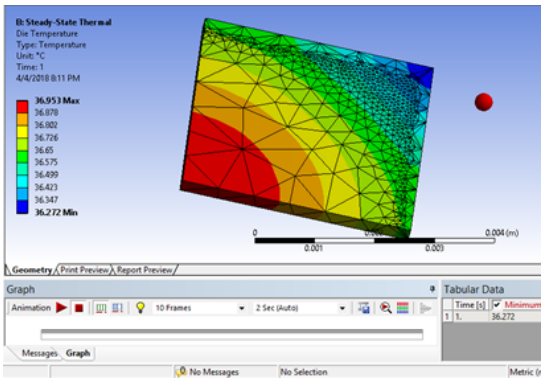

Figure 11: TQFP Die Temperature curves

4.6 Icepak Analysis of Delamination between Die and Die Attach in a TQFP

To test the proficiency and analysis skills acquired through my electronic packaging course, I decided to **study the effect of delamination between the die and the die attach of a TQFP.** A TQFP with its components and the PCB were designed in ANSYS Spaceclaim with a JEDEC setup in ANSYS Icepak simulation suite to investigate the core temperatures, thermal distribution and their variation with the introduction of an air gap, represented by a plate with the thermal conductivity of air between the die and the die attach, which was variated in different trials to understand the effect at different levels of delamination.

The effective thermal resistance was also calculated across the die and die attach to evaluate a measurable parameter than can be used to observe the effect of the delamination and its extent. The Thermal Temperature distributions at 0% and 100% delamination can be seen below.

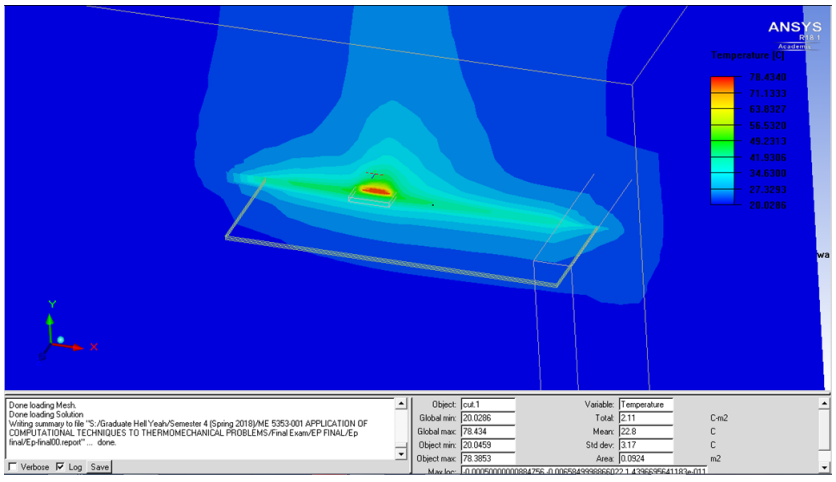

Figure 12: Termperature distribution at 0% delamination

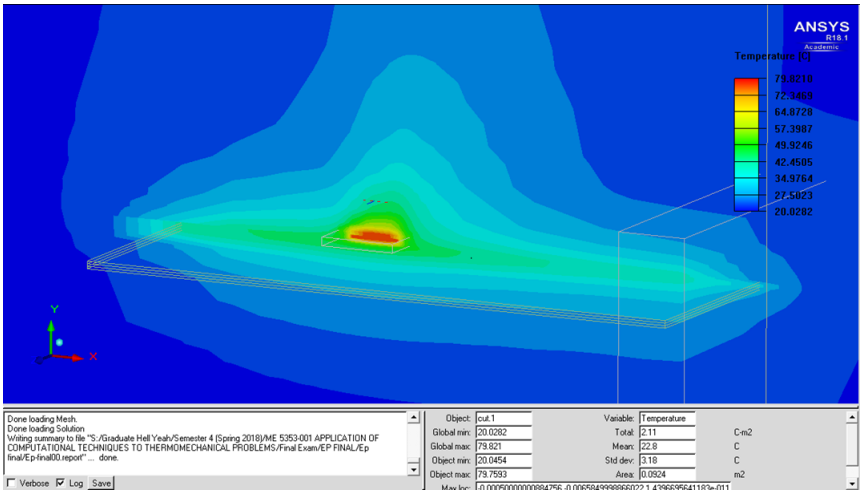

Figure 13: Termperature distribution at 100% delamination

4.7 Wind Power Generation and Prediction

The placement of a Wind turbine and its precise location can be a big challenge to determine, it requires extensive study of the weather and climate of the location, past trends of parameters such as wind direction and speed. Such data can be unreliable or in some cases missing which can be tall hurdle to cross. This project included an extensive review of literature and its application to explore a new type of computational technique in the renewable energy field. **Power prediction analysis using computer software and advanced techniques like the employment of Artificial Neural Networks (ANNs) in a coding suite (MATLAB) to better predict certain parameters and environment data which can be vital for determining the precise installation location of a Wind Turbine.**

The fundamentals of wind turbine design come into play, and to understand the effect of various parameters on the overall utilization of a wind turbine, it becomes necessary to understand the underlying phenomenon and crucial aspects such as the type of turbine, height, average wind speed etc. After gaining in-depth knowledge about such components I borrowed an unconventional approach to the prediction of the turbine location. Neural Networks provide a whole new perspective in making predictive calculations, such as working with an incomplete set of input data and yet provide an output that can be in an acceptable tolerance range. This was my first exposure to a relatively unknown prospective exploration and predictive technique that can be a game changer in many fields like placement of solar power fields, precision in weather predictions, oil field exploration and pretty much any field that had unreliable or dynamic input data, and in certain cases even missing data.

5 Appendix

5.1 MATLAB Code Links

3.1 MATLAB code for inhomogeneous 2-D Heat Equation
3.6 MATLAB code for V-Belt Design

5.2 Abbreviations

ADI	Alternate Direction Implicit
ANN	Artificial Neural Networks
CAD	Computer Aided Design
CNC	Computer Numerically Controlled
DFMEA	Design Failure Mode and Effect Analysis
FMEA	Failure Mode and Effect Analysis
GD&T	Geometrical Dimensioning and Tolerancing
HVAC	Heating, Ventilation and Air Conditioning
ITER	International Thermo-Nuclear Experimental Reactor
ONGC	Oil and Natural Gas Corporation
PDE	Partial Differential Equations
PCB	Printed Circuit Board
TQFP	Thin Quad Flat Package
TSOP	Thin Small Outline Package

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