Exponent®
Engineering & Scientific Consulting

Matthew Perrella, Ph.D., P.E.

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Professional Profile

Dr. Perrella uses his fluid dynamics expertise and broad knowledge of mechanical engineering to solve complex, multi-disciplinary problems in a wide variety of industries. He has supported his clients in matters involving product improvements, product recalls, product defect litigation, construction defect litigation, regulatory compliance, insurance disputes, and international arbitration. His experience encompasses consumer products and medical devices (e.g. pressure cookers, coffee makers, heating pads, peristaltic pumps, and ventricular assist devices), HVAC and construction defects (e.g. humidity and biologic growth, forced air and radiative cooling, hydronic and domestic water piping, pipe ruptures, water loss, and water infiltration), industrial and manufacturing equipment (e.g., centrifugal pumps and compressors, fans, excavating and construction equipment, and commercial food processing) and cryogenic technology for the defense and private sectors (e.g., Stirling cryocoolers, liquid natural gas, liquid nitrogen, and cryocooler failure analysis and reliability).

As a consultant, Dr. Perrella uses his technical expertise to determine the root cause of consumer product failures and help improve existing designs. He is knowledgeable of the pertinent regulations and industry standards and assists clients in producing and maintaining products that are safe and effective for their consumers. Dr. Perrella has extensive experience investigating and analyzing large-scale HVAC and hydronic systems and evaluating designs against applicable building codes and industry best practices. He has helped his clients diagnose and mitigate issues such as high humidity, uncontrolled temperature, and biologic growth. Dr. Perrella also applies his broad mechanical engineering knowledge to evaluate the safety and functionality of industrial and manufacturing equipment.

Dr. Perrella is a seasoned experimentalist who specializes in developing custom experimental setups. He is proficient in a variety of measurement techniques and is well-versed in measurement uncertainly and repeatability analysis. Dr. Perrella adapts novel, scientific techniques from the laboratory to industry by condensing complex concepts into practical, targeted solutions that address the diverse needs of his clients. Dr. Perrella applies fundamental engineering principles to nebulous real-world problems to efficiently identify the core issues underlying a challenge and quickly develop solutions. He also has expertise in the detailed modeling of complex thermal and fluid systems incorporating multi-mode heat transfer, buoyancy effects, pipe flow, and porous media hydrodynamics.

Dr. Perrella has applied his expertise in fluid dynamics and cryogenic refrigeration to solve problems involving the design, testing, and production of cryogenic cooling devices, linear electric motors, and thermal management systems. Before joining Exponent, Dr. Perrella worked as a cryocooler engineer who led the design and sustainment of multiple tactical cryocooler product lines and was intimately involved in all stages of the manufacturing process. His experience with the development and manufacture of defense articles for prime contractors spans conceptual design, detailed design, material procurement, production readiness assessment, and verification testing. Dr. Perrella is proficient at troubleshooting Stirling cryocoolers and similar devices and possesses hands-on experience with performance evaluation, reliability testing, root-cause analysis, and failure analysis due to material

defects, vendor defects, and workmanship. He is conversant in geometric tolerancing, machining best practices, and evaluating components against various MIL-STD and ASME specifications. His doctoral research involved the development of hydrodynamic resistance parameters for oscillating fluid flow through the porous media of cryocooler regenerators at cryogenic temperatures and the theoretical modeling of novel pulse-tube cryocooler concepts for space applications.

Academic Credentials & Professional Honors

Ph.D., Mechanical Engineering, Georgia Institute of Technology, 2017

M.S., Mechanical Engineering, Georgia Institute of Technology, 2015

B.S., Mechanical Engineering, Auburn University, 2012

Licenses and Certifications

Professional Engineer, Georgia, #PE048670

Professional Engineer, North Carolina, #053885

Professional Engineer, Tennessee, #128905

Professional Engineer, Texas, #153178

Professional Engineer, Virginia, #0402069856

Prior Experience

Cryocooler Engineer Specialist, L3Harris | Space & Sensors, 2017-2019

Graduate Research/ Teaching Assistant, Georgia Institute of Technology, 2012-2017

Mechanical Engineering Intern, Raytheon Space and Airborne Systems, 2016

Quality Control/ Design Engineer, Focus Engineering, 2012

Intern, Naval Surface Warfare Center, 2011

Co-op, VT Miltope, 2008-2010

Professional Affiliations

The American Society of Mechanical Engineers (ASME)

The American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)

Publications

Perrella, M., and Mostafa Ghiaasiaan, S., 2021, “Hydrodynamic Resistance Parameters of Regenerator Filler Materials at Cryogenic Temperatures,” Cryogenics (Guildf)., 117(May), p. 103320.

Presentations

Periodic Flow Hydrodynamic Resistance Parameters for ErPr Rare-Earth Regenerator Material at Cryogenic Temperatures, CEC, 2015

Periodic Flow Hydrodynamic Resistance Parameters for Multiple Regenerator Filler Materials at Cryogenic Temperatures, ICC 19, 2016

Development of a miniature Stirling cryocooler for LWIR small satellite applications, TTDR II, 2017

Project Experience

Consumer Products

Tested and analyzed 5+ pressure cooker designs to evaluate the performance of their various built-in safety mechanisms

Devised a custom experimental setup to measure the torque required to open a pressure cooker as a function of internal cooker pressure

Constructed an apparatus to remotely attempt to force open an operating pressure cooker as described by the UL130 pressure cooker standard

Used compressed air to simulate a pressure cooker over pressurization event and evaluate the response of the built-in safety mechanisms

Created a rapid prototype venturi device to improve the milk-frothing functionality of an espresso machine

Determined the root cause of product overflow in an espresso machine and quickly designed and implemented potential solutions to improve performance

Assessed the operation of a high-end automatic coffee maker in relation to an alleged water loss incident

Inspected and analyzed an orbital sander for defect or damage with regards to an alleged malfunction

Tested, evaluated, and analyzed numerous heating pad and heated blanket designs from multiple manufactures to assess safety, reliability, and compliance with pertinent standards and codes

Inspected a battery-powered recliner as part of a fire origin and cause investigation

Constructed a custom experimental setup to perform acute overload and cyclical overload testing of a wooden bunk bed to evaluate potential design improvements

Worked with a multi-disciplinary team to determine the root cause of premature coffee cup lid failures

Medical Devices

Evaluated potential design improvements to reduce noise and improve flow rate stability in a breath delivery unit (BDU), also known as a ventilator, using both off-the-shelf and custom, rapid prototyped components

Designed a custom experimental apparatus and suite of experiments to test and evaluate peristaltic pumps

Designed a custom experimental apparatus using laser micrometers to collected vibration data for ventricular assist devices (VAD), also known as heart pumps, and analyzed the vibration data to inform manufacturing quality improvements and increase product life

Analyzed failure logs and software for a peristaltic pump controller in support of a risk assessment

Heating, Ventilation, Air Conditioning and Refrigeration (HVAC-R)

Inspected a commercial beverage cooler in support of a fire origin and cause investigation

Determined the root cause of a cooling tower pipe rupture and evaluated the robustness of the freeze protection design and the appropriateness of the attempted coil repair

Assessed the validity of moisture infiltration claims do to an allegedly defective attic design

Analyzed the condenser water loop of a high-rise HVAC system to determine the root cause of a hydronic piping rupture and subsequent water loss

Evaluated the design of an integrated condenser water and fire protection system (non-fire protection connections) to determine its compliance with the applicable plumbing, mechanical, and fire protection codes

Analyzed temperature and humidity data of a multi-use apartment building to assess the validity of alleged moisture infiltration claims from an adjacent commercial space

Investigated the design and installation of a manufacturing facility's ventilation and exhaust air flows and air filtration systems to determine its compliance with building specifications, building codes, and industry guidance

Led the testing and inspection of a residential HVAC and temperature control system to determine the root cause of an alleged overheating event

Mapped the damage patterns and moisture distribution inside of a high-rise hotel to determine the root cause of alleged biologic growth

Inspected the installation of vertical terminal air conditioning (VTAC) units inside of a luxury hotel to determine the root cause of controller board failures

Reviewed the design of a packaged terminal air conditioning (PTAC) unit to assist with noise mitigation efforts

Analyzed temperature and humidity data within a luxury high-rise hotel to evaluate the effectiveness of the radiant beam (chilled beam) cooling/heating system

Collected and analyzed temperature and humidity data within a Designated Outdoor Air System (DOAS) to determine the root cause of high humidity conditions within the operating rooms of a hospital

Analyzed the temperature and humidity output of the Makeup Air Units (MAU) at a high-rise hotel to determine the root cause of high humidity and biologic growth within the building

Instrumented cruise ship refrigeration lines to record surface temperature and ambient humidity measurements and determine the root cause of pipe condensation issues

Evaluated the design and installation of a residential air handling unit to determine the cause of alleged high humidity and biologic growth

Determine the root cause and prevalence of condensation within the cold-water hydronic system of a high-rise apartment building

Researched the effect of water treatment and filtration on the efficiency of an external melt, ice tank thermal energy storage system and evaluated the advantages and disadvantages of external melt versus internal melt systems

Performed a detailed failure analysis of a resistive duct heater and the associated temperature control components in support of a fire investigation

Measured and documented the displacement of a hospital's chilled water hydronic system following a pipe rupture and water release to inform corrective and preventative actions

Analyzed the temperature and humidity data of a hotel's multiple Outdoor Air Handling Units (OAHUs) to determine the root cause of observed biologic growth and evaluate proposed mitigation strategies

Construction

Evaluated the design and installation of a storm water drainage system of a large warehouse to inform a cost-of-repair analysis

Assessed the regulatory compliance of a passive radon mitigation system against relevant building codes and standards

Analyzed the design and construction of the HVAC and hydronic systems for a large, multi-staged mall development as part of an international arbitration

Measured and analyzed pressure and flow rates within domestic cold water and hot water recirculation systems with regards to alleged failures of crosslinked polyethylene (PEX) and polypropylene piping

Researched standards for building underpinning safety and evaluated documented procedures and practices against the applicable standards

Inspected and analyzed the installation of sanitary drain lines at an apartment complex for compliance with applicable building codes

Calculated head loss versus pump performance to evaluate the suitability of the sump pump system design in a luxury apartment building

Industrial

Performed a detailed computation fluid dynamics (CFD) simulation of an industrial food drying oven to identify potential hot spots in support of a fire origin and cause investigation

Evaluated the design and installation of a gas-fired industrial food drying oven for compliance with NFPA standards and manufacturer recommendations

Developed a high-fidelity computation fluid dynamics (CFD) model to calculate the forces exerted on a diver during a transient delta pressure event at a hydroelectric power plant

Documented the displacement of a liquified natural gas (LNG) pipeline to assist with remedial efforts

Calculated the volume of oil released and recovered following a pipeline rupture using analytical and computational analysis of geographical, pressure, and flow rate data

Evaluated the design and operator instructions of a front-discharge cement mixer for compliance with the relevant industry standards

Designed a custom suite of experiments to inform and evaluate safety improvements for pneumatic printing press roller adapters

Inspected and tested linear actuators for solar panel installations to determine the root cause of field failures

Evaluated the design of an industrial air duct system against nationally-recognized design standards (Sheet metal and Air Conditioning Contractors' National Association – SMACNA)

Investigated an incident involving overheating within a self-priming centrifugal pump being used for sewage bypass

Investigated a fire within a multi-stage centrifugal compressor at a liquid natural gas (LNG) processing facility and performed root cause analysis

Researched the operator presence sensors and automatic breaking functions of commercial crawler dozers to evaluate the standard of care for such safety devices

Performed industry research of 100 hp front end loaders and mulcher attachments to evaluate the standard of care for the safe design of such machines

Analyzed the design of an agricultural dump wagon to evaluate it against ANSI and ASAE standards and peer products available in the market

Evaluated the tip over prevention design of a scissor lift against ANSI and OSHA standards and peer products

Cryogenics and Defense

Led a root cause investigation for a case involving liquid nitrogen (LN2) burns allegedly sustained during use of a portable inflatable cryogenic sauna including a detailed review of the equipment design and state of the art

Investigated an alleged failure of a liquid nitrogen (LN2) sensing tube for a commercial food processing facility

Performed a scooping analysis and trade study to estimate the theoretical cooling capacity of a 1-watt split Stirling cryocooler as a function of compressor input power and size

Investigated alternative regenerator filler materials using additive manufacturing techniques for use in a 200 mW split Stirling cryocooler regenerator

Calculated the Mean Time to Failure (MTTF) and reliability for a 1-watt split Stirling cryocooler based on a Weibull distribution using return data, shipment history, and approximate product exposure rates

Developed a 1-dimensional oscillatory steady state thermodynamic model of a 1-watt split Stirling cryocooler using Sage cryocooler modeling software to evaluate potential design improvements

Intellectual Property

Assessed the validity of license agreement infringement claims involving a patented refrigeration compressor technology

Evaluated the efficacy of pet food marketing claims using fluid dynamics analysis

Performed a literature review on self-balancing hydraulic systems for on-road and off-road applications and researched commercially available hydraulic solenoid valves to assess issues of novelty and non-obviousness is support of a patent infringement investigation