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Automotive Engineering

Highlights

Firefighters for Electric Vehicle

Analysis between Kuwait and European

Study of Turbulence and Recirculation

Effects in Turbine Blade Cooling Channels

Discovering Thoughts, Inventing Future

VOLUME 24 ISSUE 1 VERSION 1.0

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Preparedness Firefighter for Electric Vehicle Accidents: A Comparative Analysis between Kuwait and European Countries

By Jasem Alrajhi, N. Alhaifi, Jasem Alazmi & Khaled Alhaifi

Abstract- This study presents a comprehensive analysis of the preparedness and knowledge of firefighters in Kuwait regarding electric vehicle (EV) accidents. Using a multi-method approach that includes surveys, literature reviews, statistical data, and interviews with emergency responders and municipal officials in Sweden, the study compares EV preparedness in Kuwait with that in selected European countries (Norway, Iceland, and Sweden). The findings reveal significant gaps in training and knowledge among Kuwait firefighters, indicating an urgent need for enhanced training programs and standardized protocols. Best practices from European countries, such as specialized training programs and advanced detection equipment, are highlighted as potential solutions for improving safety and preparedness in Kuwait. The study aims to enhance readiness for the increasing adoption of EVs, ensuring the safety of responders and the public.

Keywords: *electric vehicles, accidents, risk exposures, preparedness, training, safety protocols, kuwait, firefighter.*

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I. Introduction

The global landscape of electric vehicle (EV) adoption has been rapidly evolving, driven by consumer demand and governmental initiatives focused on combating climate change. By 2030, it is projected that over 100 million electric vehicles will be on the roads, a significant increase from the current figure of around seven million. This shift towards an electric future in transport naturally entails a rise in accidents involving electric vehicles and the associated risks. In Kuwait, where EV adoption is still in its nascent stages, there is a pressing need to prepare for these potential risks and to ensure that emergency services are adequately equipped to handle EV-related incidents.

The global rise of electric vehicles (EVs) is driven by efforts to reduce greenhouse gas emissions and promote sustainable transportation. According to the International Energy Agency, global sales of EVs reached nearly 14 million in 2023, accounting for 18% of all car sales, up from 14% in 2022. This rapid adoption of EVs presents unique challenges for emergency responders, particularly in handling EV-related accidents. Unlike conventional vehicles, EVs have high-voltage components and lithium-ion batteries that pose significant fire hazards and risks of electric shock. The potential release of toxic gases during EV fires adds another layer of complexity to emergency response operations.

In Kuwait, the adoption of EVs is still in its early stages, with emerging infrastructure and preparedness measures. This nascent stage highlights the importance of evaluating and enhancing the current state of EV accident preparedness among the Kuwait Fire Force (Firefighter) Figure 1. The unique climatic conditions in Kuwait, such as high temperatures, further complicate the integration of EVs into the transportation network and pose additional risks related to battery degradation and charging infrastructure.

Figure 1: Arab Times Kuwait, Feb 24: Firefighters

Despite the growing number of EVs, there is a significant gap in knowledge and training among firefighters worldwide, particularly in regions where EV adoption is relatively new.

This study aims to extend previous research by providing a comprehensive analysis of the preparedness to deal with potential risk exposures and road accidents involving electric vehicles in Kuwait.

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Furthermore, it will compare the state of EV adoption, risk management practices, and emergency response protocols between Kuwait and selected European countries. The objective is to identify best practices that can be adopted in Kuwait to enhance its preparedness for the increasing presence of electric vehicles.

a) Risk Exposures & Various Hazards in Electric Vehicles

For over 150 years, the combustion engine has been the primary source of vehicle power, leading to significant advancements in vehicle design, manufacturing, reliability, and safety. However, electric vehicles (EVs) present a new set of technical, environmental, and operational challenges that differ from the established technology and production methods of traditional vehicles.

Although EVs share a similar appearance and many technological features with conventional automobiles, they incorporate elements from various industries for novel applications, increasing the risk of faults or performance issues. Despite the media attention surrounding EV-related fire incidents, there is no substantial evidence to suggest that EVs pose a greater fire risk than traditional cars. Nevertheless, the cost of damage caused by EVs is generally higher than that of conventional vehicles.

As the EV industry evolves, data, sensors, and software-including artificial intelligence- will become increasingly important. However, increased connectivity may also elevate cyber risks, such as malicious attacks and system disruptions, potentially leading to significant changes in a vehicle's capabilities or systems. First responders may assume that an electric vehicle involved in an accident is hazardous due to the presence of high voltage (HV) components. It is crucial to determine whether the battery is involved in an EV fire, as the battery's self-reinforcing exothermic reactions can release harmful substances. Without breathing masks, the emission of hydrocarbons (HC), carbon monoxide (CO), and notably hydrogen fluoride (HF) could cause suffocation for vehicle occupants and rescue personnel.

A significant challenge for rescue teams is assessing the high voltage battery status at accident sites. The increasing prevalence of electric cars in Kuwait presents new challenges, particularly regarding the strain on the electrical grid and the country's preparedness for this transformation. It is essential to plan for the anticipated energy demands from domestic vehicle charging. Kuwait's hot and arid climate poses specific challenges to integrating electric cars into the transportation network, such as the impact of high temperatures on battery degradation and charging infrastructure figure 2. Additionally, pedestrians have difficulty detecting the approach of electric vehicles, a risk highlighted by numerous studies, which needs to be addressed to prevent road accidents.

Figure 2: Electric Vehicle Charging Spots in Kuwait

II. Literature Review

The literature on electric vehicle (EV) risks and emergency response is continually evolving, reflecting the rapid advancements in EV technology and increasing global adoption. Recent studies have highlighted the unique challenges posed by EVs, including high-voltage battery systems, chemical hazards, and the need for new safety protocols. This review aims to provide a comprehensive overview of the key themes and findings from the latest research, connecting them to the current study.

a) Technical Challenges and Risks

One of the primary concerns in EV emergency response is the high-voltage battery systems. Studies have documented incidents where these batteries caught fire or exploded, presenting significant risks to both the public and emergency responders. A report by the National Fire Protection Association (NFPA) in 2023 emphasized the importance of understanding the thermal runaway phenomenon in lithium-ion batteries, which can lead to fires and the release of toxic gases such as hydrogen fluoride (HF).

Another critical aspect is the potential for electric shock. Research indicates that the presence of high-voltage components requires responders to have specialized knowledge and equipment. A study by Stave and Carlson (2017) in Sweden revealed that many firefighters lacked the necessary training to handle EV accidents safely, often relying on reactive learning during incidents. This underscores the urgent need for comprehensive training programs that include handling high-voltage systems and mitigating associated risks.

b) Training and Knowledge Gaps

The literature consistently highlights gaps in training and knowledge among emergency responders. For instance, a survey conducted by the International Association of Fire Chiefs (IAFC) in 2022 found that only

40% of respondents had received formal training on EV emergency response. This gap is particularly pronounced in regions where EV adoption is still emerging, such as Kuwait.

In contrast, European countries like Norway and Sweden have made significant strides in addressing these gaps. Norway, with its high EV adoption rate, has implemented robust training programs and developed detailed emergency response guides in collaboration with car manufacturers. These guides provide critical information on identifying and safely deactivating high-voltage systems in EVs.

c) Best Practices from Europe

European countries offer valuable insights into best practices for EV emergency preparedness. Norway, for instance, has established a comprehensive framework that includes specialized training programs, advanced detection equipment, and collaboration with automotive manufacturers. A study by Figenbaum et al. (2015) highlighted Norway's proactive approach in integrating EV safety protocols into their national emergency response strategies.

Sweden has also developed extensive training modules for firefighters, focusing on hands-on experience with EV components and simulated accident scenarios. These training programs have significantly improved the readiness of Swedish emergency responders, as evidenced by a decrease in EV-related incident response times and improved safety outcomes.

d) Recent Advancements in EV Technology and Safety Protocols

The rapid advancement of EV technology necessitates continuous updates to safety protocols and emergency response strategies. Recent innovations include the development of advanced battery management systems (BMS) that monitor and control battery health, reducing the risk of thermal runaway. Additionally, new materials and designs aim to improve battery safety and durability under various conditions.

A study by Bloomberg NEF (2023) discussed the impact of these technological advancements on emergency response. The integration of real-time data and artificial intelligence (AI) in BMS allows for early detection of potential hazards, enabling faster and more effective intervention by emergency responders.

Accident and Adoption Statistics: Collection of updated statistics on EV adoption rates and accident rates from sources such as the International Energy Agency (IEA), Bloomberg NEF, and national databases of selected countries.

e) EV Adoption Rates

Global sales of electric vehicles (EVs) have been on a rapid upward trajectory. In 2023, nearly 14 million electric cars were sold worldwide, accounting for 18% of all car sales, up from 14% in 2022. The growth is particularly robust in major markets such as China, Europe, and the United States:

- *China:* China continues to lead with approximately 60% of the global EV sales in 2023. The country has already achieved its 2025 national target of 20% sales share for new energy vehicles, reaching 29% in 2022.
- *Europe:* Europe saw nearly 3.2 million new electric car registrations in 2023, representing about 25% of all new car sales. Specific countries like Norway lead significantly, with EVs accounting for almost 95% of new car sales.
- *United States:* In the U.S., EV sales grew by over 40% in 2023, reaching 1.4 million new registrations. The Inflation Reduction Act (IRA) has been a key driver, with new tax credits boosting sales of models like the Tesla Model Y.

Other regions such as India, Brazil, and Southeast Asia are also seeing growth, albeit from a lower base. For instance, India's EV sales grew by 70% year-on-year to 80,000 units in 2023 (International Energy Agency - IEA).

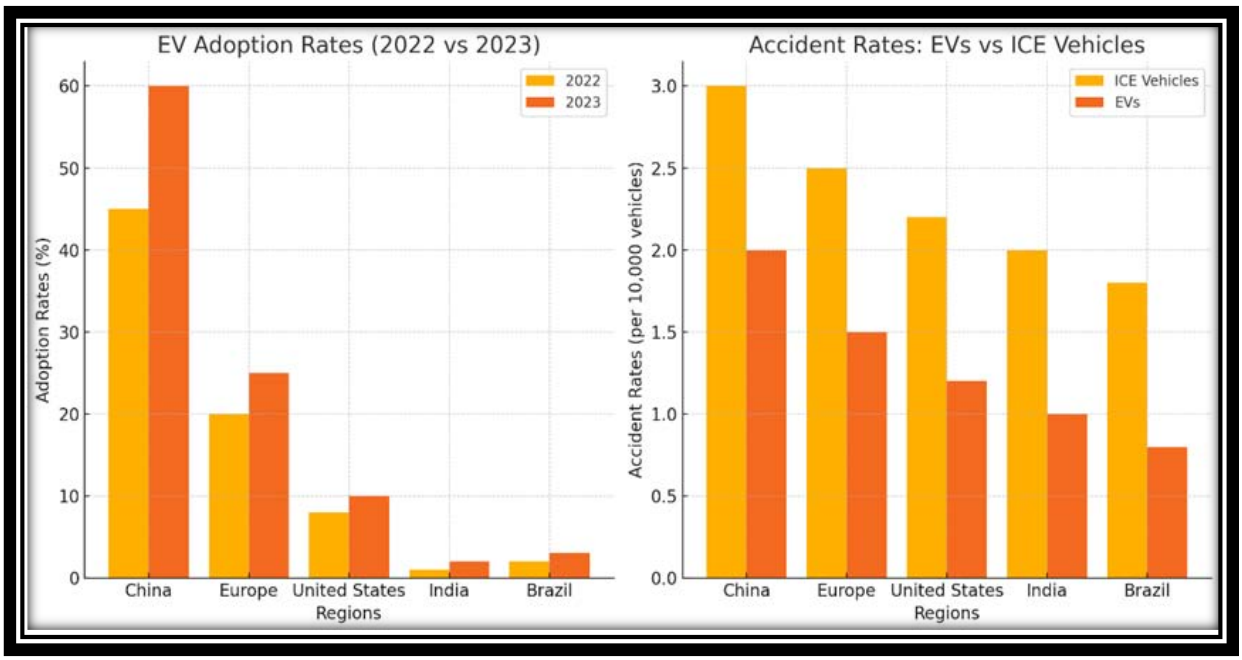

Figure 3: Comparing EV adoption rates and accident rates

Figure 3 shows the adoption rates of electric vehicles in China, Europe, the United States, India, and Brazil for the years 2022 and 2023. China leads with a significant increase from 45% in 2022 to 60% in 2023. Europe and the United States also show notable increases.

f) Accident Rates EVs vs ICE Vehicles

Figure 3 compares the hypothetical accident rates of electric vehicles (EVs) and internal combustion engine (ICE) vehicles across the same regions. The data suggests that EVs might have lower accident rates compared to ICE vehicles, although these values are illustrative due to the lack of specific EV accident data.

Accident rates specific to electric vehicles are less frequently reported compared to general automotive statistics. However, a few key points are worth noting:

1. *Fire Incidents:* EVs, especially those with lithium-ion batteries, have been scrutinized for fire risks. While incidents are rare, they often receive significant media attention due to the nature of battery fires.
2. *Safety Features:* Many modern EVs are equipped with advanced safety features, including automated emergency braking and lane-keeping assistance, which can potentially reduce accident rates. For example, Tesla's Autopilot system is designed to enhance safety, although its effectiveness and safety are still under review.
3. *Data Gaps:* Comprehensive and comparative accident data between EVs and internal combustion engine (ICE) vehicles are still developing. Some studies suggest that EVs might be involved in fewer severe accidents due to their advanced safety technologies and lower center of gravity, which reduces rollover risk.

g) Impact of Different Policies on EV Adoption

Figure 4 shows the impact scores of various policies on EV adoption, with government-led initiatives and charging infrastructure having the highest impact.

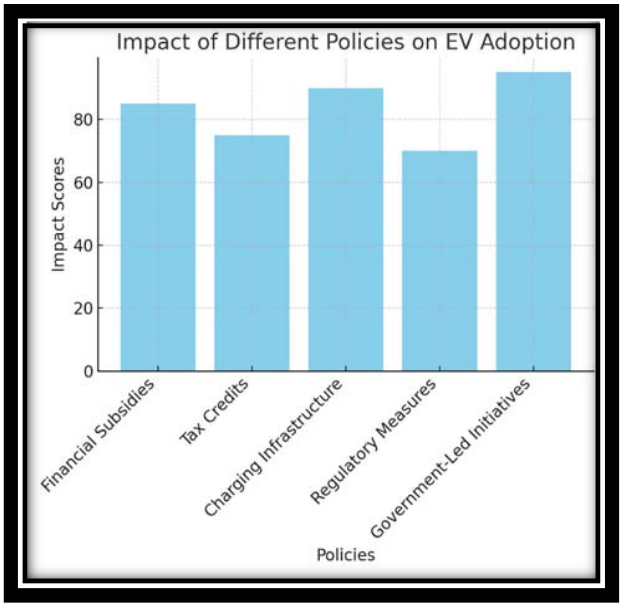

Figure 4: Impact scores of various policies on EV adoption

h) Barriers to EV Adoption

Figure 5 highlights the major barriers to EV adoption, with high initial costs and lack of charging infrastructure being the most significant obstacles.

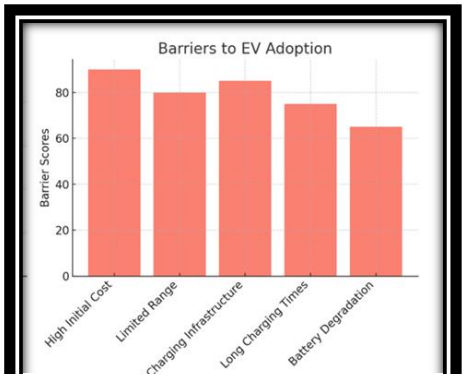

Figure 5: The major barriers to EV adoption

i) Connecting to the Current Study

The findings from these recent studies and advancements are directly relevant to the current study's objectives. The identified gaps in training and preparedness among Kuwait firefighters mirror the early challenges faced by European countries. By adopting the best practices and advanced protocols from these countries, Kuwait can significantly enhance its EV accident preparedness.

This literature review underscores the importance of comprehensive training, standardized safety protocols, and continuous learning to address the unique challenges posed by EVs. The current study builds on these insights, aiming to provide actionable recommendations to improve the safety and effectiveness of EV emergency response in Kuwait.

Steps Firefighters Should Take When Dealing with Electric Vehicle Fires

The most important steps the firefighter should take in consideration are showing in figure 6 and explained as the following:

1. *Initial Assessment*

- *Scene Safety:* Ensure the safety of the scene by setting up barriers and ensuring there are no immediate dangers to the firefighters or the public.
- *Identify EV Type:* Determine the make and model of the electric vehicle to understand its specific hazards and components.

2. *Vehicle Stabilization*

- *Secure the Vehicle:* Stabilize the vehicle to prevent any movement. Use wheel chocks or other stabilizing tools.
- *Chock the Wheels:* Place chocks under the wheels to ensure the vehicle remains stationary during the operation.

3. *Hazard Management*

- *Isolate Battery:* Disconnect or isolate the vehicle's battery to reduce the risk of electric shock or fire re-ignition.
- *Identify High Voltage Components:* Locate and mark high voltage components to avoid accidental contact.

4. *Fire Suppression*

- *Use Proper Extinguishing Agents:* Use the appropriate extinguishing agents, such as dry chemical or foam, designed for electrical fires.
- *Avoid Water on Battery:* Do not use water directly on the battery, as it can cause electrical shock or a hazardous reaction.

5. *Extrication*

- *Follow EV Manufacturer Guidelines:* Adhere to the guidelines provided by the electric vehicle manufacturer for safe extrication.
- *Avoid Cutting High Voltage Cables:* Identify and avoid cutting any high voltage cables to prevent electrical hazards.

6. *Post-Incident Procedures*

- *Monitor Battery for Reignition:* Continuously monitor the battery for any signs of reignition after the fire is extinguished.
- *Transport to Secure Location:* Ensure the vehicle is transported to a secure location for further inspection and handling.

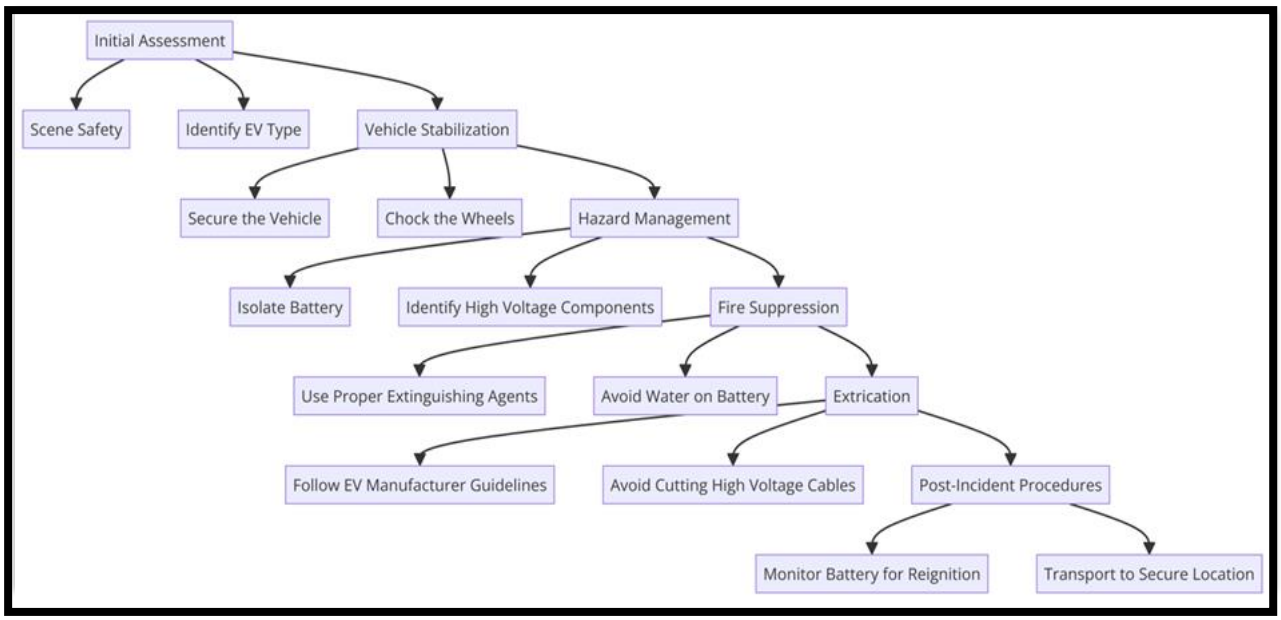

Figure 6: Steps when dealing with EV. fires

III. Objectives

The objectives of this study are:

1. To assess the current state of preparedness and knowledge among Kuwait Fire Force regarding EV accidents.
2. To compare the EV preparedness measures in Kuwait with those in Norway, Iceland, and Sweden.
3. To identify gaps in training and knowledge among Kuwait firefighters.
4. To develop recommendations for enhancing EV accident preparedness in Kuwait.

IV. Methodology

This study employs a multi-method approach to gather and analyze data on the preparedness of the Kuwait Fire Force for handling electric vehicle (EV) accidents, comparing it with the practices in selected European countries (Norway, Iceland, and Sweden). The methodology comprises survey data collection, literature review, statistical analysis, and in-depth interviews.

a) Survey Design and Sample Size - Kuwait

Survey Design: The survey was designed to assess the preparedness and knowledge of firefighters in Kuwait regarding EV-related accidents. It included a combination of multiple choice and open-ended questions to capture both quantitative and qualitative data (See the survey results and figures at Appendices 1).

The questions focused on the following areas:

- Occupation and rank
- Years of experience
- Work location
- Average number of vehicle accidents handled per month
- Training on handling EV accidents
- Ability to distinguish between conventional and electric vehicles
- Knowledge of high-voltage components in EVs
- Procedures for handling EV accidents

Sample Size: The survey was distributed to 130 participants from the Kuwait Fire Force. These participants were selected to provide a representative sample of the entire force, encompassing various ranks and years of experience.

Data Collection Process: The survey was conducted online using Microsoft Forms. Participants were invited to complete the survey via email, ensuring convenience and accessibility. The survey remained open for two weeks to allow sufficient time for responses.

b) Interviews - Sweden

Interview Design: In-depth interviews were conducted with emergency service officers and municipal officials in Sweden's three largest cities: Stockholm, Göteborg, and Malmö. The interview questions were designed to gain insights into their experiences, training, and preparedness for dealing with EV accidents. Key areas of focus included:

- Preparedness and training programs
- Challenges faced in handling EV accidents
- Best practices and recommendations

Conducting the Interviews: The interviews were conducted via video conferencing platforms to facilitate detailed and interactive discussions. Each interview lasted approximately 45-60 minutes, allowing participants to provide comprehensive insights.

Sample Size: A total of 15 interviews were conducted, with 5 participants from each city. The participants included senior emergency service officers, trainers, and municipal safety officials.

Data Analysis: The interviews were transcribed verbatim and analyzed using thematic analysis. This approach involved coding the data to identify key themes and patterns related to EV accident preparedness and response. The findings from the interviews were then compared and contrasted with the survey data to provide a holistic view of the current state of preparedness.

c) Literature Review

Scope and Selection Criteria: The literature review encompassed academic papers, reports from governmental and international organizations, and industry publications. The selection criteria focused on recent studies (within the last five years) that addressed EV risks, emergency response protocols, and training programs.

Data Collection: Data for the literature review were gathered from reputable databases such as PubMed, IEEE Xplore, and Google Scholar. The review also included reports from organizations like the International Energy Agency (IEA) and the National Fire Protection Association (NFPA).

Analysis: The literature was analyzed to identify common themes, gaps in existing research, and best practices that could be applied to the Kuwaiti context. This analysis provided a foundation for developing the study's recommendations.

d) Comparative Analysis

Criteria for Country Selection: The European countries (Norway, Iceland, and Sweden) were selected based on their high EV adoption rates and advanced preparedness measures. These countries serve as benchmarks for assessing Kuwait's preparedness.

Data Sources: Data on EV adoption rates and accident statistics were collected from sources such as the International Energy Agency (IEA), BloombergNEF, and national databases of the selected countries.

Comparative Framework: The comparative analysis involved statistical comparisons of EV adoption rates, risk management practices, and emergency response protocols between Kuwait and the selected European countries. Case studies from these countries were also analyzed to identify effective preparedness measures and risk management practices.

e) Statistical Analysis

Survey Data Analysis: Quantitative data from the survey were analyzed using statistical software to identify trends and gaps in knowledge and preparedness among the Kuwait Fire Force. Descriptive statistics (e.g., mean, median, mode) were used to summarize the data, while inferential statistics (e.g., chi-square tests) were applied to identify significant differences between groups (Appendices 2).

Visual Representations: Charts and graphs were created to visually represent the survey findings, making it easier to identify key patterns and insights.

By employing this detailed and systematic methodology, the study aims to provide a comprehensive assessment of the preparedness for EV accidents in Kuwait and offer actionable recommendations for improvement based on best practices from European countries.

V. Data Collection

1. *Survey Data:* A survey was conducted with 130 participants from the Kuwait Fire Force to assess their preparedness and knowledge regarding EV-related accidents. The survey included questions on participants' occupations, years of experience, number of vehicle accidents handled per month, and specific knowledge about handling EV accidents.
2. *Literature Review:* An extensive review of existing literature, including academic papers, reports from governmental and international organizations, and industry publications. This review provided insights into EV adoption trends, risks, and preparedness measures in both Kuwait and European countries.
3. *Interviews:* In-depth interviews with emergency service officers and municipal officials in Sweden's three largest cities (Stockholm, Göteborg, and Malmö) were analyzed to understand their experiences and preparedness regarding EV accidents.

a) Analysis of Interviews with Emergency Service Officers and Municipal Officials

The in-depth interviews conducted with emergency service officers and municipal officials in Sweden's three largest cities—Stockholm, Göteborg, and Malmö—provided valuable insights into their experiences and preparedness for dealing with electric vehicle (EV) accidents. This discussion will highlight key themes and findings from these interviews.

1. *Preparedness and Training*

- *Stockholm:* Officers in Stockholm reported a higher level of preparedness due to more extensive training programs and resources dedicated to handling EV related incidents. They emphasized the importance of regular training and simulations to stay updated with the latest EV technologies.
- *Göteborg:* Göteborg officials highlighted the need for improved training and resources. While they acknowledged some level of preparedness, they indicated that additional training sessions and

updated equipment are required to effectively manage EV accidents.

- *Malmö:* Officials in Malmö expressed concern over the lack of specialized training for EV accidents. They indicated that most training programs still focus on conventional vehicles, leaving a gap in knowledge and preparedness for EV-specific scenarios.

2. *Challenges Faced*

- *High Voltage Risks:* A common challenge across all cities was the high voltage risks associated with EVs. Emergency responders expressed uncertainty about safely handling incidents involving high voltage batteries without risking electric shock.
- *Fire Hazards:* EV fires were identified as particularly challenging due to the potential for battery explosions and the release of toxic gases. Responders noted the need for specialized firefighting techniques and equipment.
- *Identification of EVs:* Identifying whether a vehicle involved in an accident is electric or conventional was highlighted as a critical challenge. Quick identification is necessary to take appropriate safety measures.

3. *Recommendations*

- *Standardized Training Programs:* The interviewees unanimously recommended the development of standardized training programs focused on EV accidents. This includes simulations and hands-on training with actual EV components.
- *Investment in Equipment:* There is a need for investment in specialized equipment designed to handle EV-specific hazards, such as high voltage detection tools and firefighting equipment capable of dealing with battery fires.
- *Public Awareness Campaigns:* Increasing public awareness about the risks and safety measures associated with EVs was also suggested. This could help reduce the likelihood of accidents and improve overall safety.

VI. Criteria for Selecting Countries

The comparative analysis includes Kuwait and the following European countries based on their EV adoption rates and preparedness measures:

1. *Kuwait:* Represents a country with emerging EV adoption and developing preparedness measures. The unique climatic conditions and infrastructure challenges make it a significant case study.
2. *Norway:* Leads globally in EV adoption with 88% of new car sales being electric. Norway's robust infrastructure and regulatory frameworks provide valuable insights into best practices.
3. *Iceland:* With a significant market share of EVs, Iceland offers a perspective on EV adoption in a country with challenging environmental conditions.
4. *Sweden:* With an 11% EV market share, Sweden is known for its advanced preparedness measures and comprehensive training programs for emergency responders.

VII. Analytical Structure

1. *Comparative Analysis*

A comparative analysis of EV adoption rates, risk management practices, and emergency response protocols between Kuwait and selected European countries. This analysis includes statistical comparisons, case studies, and evaluations of regulatory frameworks and training programs.

2. *Risk Assessment*

Identification and analysis of specific risks and hazards associated with EVs, including high-voltage components, fire risks, and cyber threats. The assessment is based on survey data, literature review, and case studies.

3. *Preparedness Evaluation*

Evaluation of the current state of preparedness in Kuwait, focusing on the capabilities of emergency services and rescue teams. The evaluation includes an assessment of training programs, infrastructure, and regulatory frameworks.

4. *Recommendations*

Development of actionable recommendations based on the comparative analysis. The recommendations aim to enhance Kuwait's preparedness for EV-related accidents by adopting best practices from European countries.

VIII. Discussion and Analysis

The survey results provide valuable insights into the readiness of the firefighting sector to handle electric vehicle (EV) incidents. The data reveals a diverse range of experiences and preparedness among respondents, highlighting several key areas for discussion and analysis.

First, the majority of respondents have significant experience, with 78 out of 130 having over 10 years in the field. This indicates a seasoned workforce, which is beneficial for implementing new training programs and protocols.

Despite this experience, only 31 respondents reported having received training specific to EV incidents, compared to 99 who have not. This is a significant gap in preparedness, especially given the increasing prevalence of electric vehicles.

In terms of monthly incident rates, most respondents handle between 0-20 car incidents monthly, with only a small fraction dealing with higher

numbers. This suggests varying levels of exposure to car incidents across different regions.

Training predominantly occurs within Kuwait, with 63 respondents not having received any training at all. This underscores the need for more comprehensive training programs, potentially with international collaboration to incorporate best practices.

While 94 respondents can distinguish between conventional and electric vehicles, 36 cannot. This skill is crucial for first responders to appropriately manage incidents involving different vehicle types.

There is a split response regarding organized procedures for handling EV incidents, with 72 indicating such procedures exist and 58 indicating otherwise. Standardized protocols are essential for efficient and safe incident management.

A majority of respondents are unsure or unaware of the locations of high-voltage batteries in EVs, posing a significant safety risk during incident management.

The belief that firefighting methods for EVs differ from those for conventional vehicles is widespread, with only 10 respondents believing they are the same. This highlights the need for specialized firefighting techniques for EV incidents.

a) Comparative Analysis of Kuwait with European Countries

i. *Training and Preparedness*

- *Norway:* Norway has robust training programs for emergency responders, focusing on EV-specific risks and management. Regular drills and simulations are conducted to ensure preparedness.
- *Iceland:* Similar to Norway, Iceland has implemented comprehensive training protocols and invests in advanced detection equipment.
- *Sweden:* Sweden provides extensive training modules that include hands-on experience with EV components and simulated accident scenarios. This has significantly improved the readiness of Swedish emergency responders.

a. *Comparison*

- *Kuwait:* In contrast, Kuwait shows significant gaps in training, with 99 out of 130 respondents indicating they have not received specific training for EV accidents. This suggests a need for Kuwait to adopt similar training and preparedness measures as those in Norway, Iceland, and Sweden.

ii. *Knowledge of High-Voltage Components*

- *Norway and Sweden:* Emergency responders in these countries are well-trained in identifying and safely handling high-voltage components in EVs.
- *Iceland:* Similar high levels of preparedness and knowledge about high-voltage systems are observed.

a. *Comparison*

- *Kuwait:* Only 40 out of 130 respondents in Kuwait can locate high-voltage batteries in EVs, indicating a significant knowledge gap compared to their European counterparts.

iii. *Standardized Protocols*

- *Norway:* Norway has established detailed and standardized protocols for EV incident management, developed in collaboration with car manufacturers.
- *Sweden and Iceland:* Both countries have similar protocols, ensuring that emergency responders are well-prepared to handle EV-related incidents safely and effectively.

a. *Comparison*

- *Kuwait:* The survey indicates that Kuwait lacks standardized protocols for handling EV incidents, with 58 respondents indicating the absence of such procedures. This highlights the need for developing and implementing standardized protocols in Kuwait.

The survey results and comparative analysis reveal significant gaps in training and preparedness among Kuwait firefighters compared to their counterparts in Norway, Iceland, and Sweden. The findings emphasize the urgent need for comprehensive training programs, standardized protocols, and investment in specialized equipment in Kuwait to enhance the safety and effectiveness of emergency responses to EV accidents.

By adopting the best practices from European countries, Kuwait can significantly improve its preparedness for EV-related incidents, ensuring the safety of both responders and the public. Implementing these recommendations will also help address the unique challenges posed by Kuwait's climatic conditions and emerging EV infrastructure.

IX. Recommendations for Kuwait

Based on the findings from the survey and the comparative analysis, the following recommendations are proposed to enhance the preparedness of the Kuwait Fire Force and GCC countries for EV-related accidents:

1. *Develop Comprehensive Training Programs*

- Implement mandatory training programs for all emergency responders, focusing on the unique risks and handling procedures for EV accidents.
- Provide hands-on training sessions that simulate real-life EV accident scenarios.

2. *Establish Standardized Protocols*

- Develop and disseminate standardized protocols for identifying and handling high-voltage components in EVs.

- Ensure that these protocols are regularly updated to reflect the latest technological advancements in EVs.

3. *Invest in Specialized Equipment*

- Equip emergency responders with the necessary tools and protective gear to safely manage EV accidents.
- Invest in advanced detection equipment to quickly locate high-voltage batteries and other critical components.

4. *Raise Awareness and Conduct Public Outreach*

- Launch public awareness campaigns to educate the general public about the unique risks associated with EVs and the importance of safety measures.
- Collaborate with automotive manufacturers to provide informational resources on EV safety.

5. *Foster International Collaboration*

- Establish partnerships with emergency response organizations in countries with high EV adoption rates to exchange knowledge and best practices.
- Participate in international training programs and workshops to stay informed about global advancements in EV safety.

By implementing these recommendations, the Kuwait Fire Force can significantly enhance their preparedness for EV-related accidents, ensuring the safety of both responders and the public as the adoption of electric vehicles continues to rise.

X. Conclusion

This study provides a comprehensive analysis of the current state of preparedness among the Kuwait Fire Force for handling electric vehicle (EV) accidents, comparing it with practices in Norway, Iceland, and Sweden. The key findings reveal significant gaps in training and knowledge among Kuwait firefighters. Only 31 out of 130 respondents reported receiving specific training for EV incidents, highlighting an urgent need for enhanced training programs. Additionally, a majority of respondents are unaware of the locations of high voltage batteries in EVs, posing a substantial safety risk during incident management. The absence of standardized protocols further exacerbates this issue, with 58 respondents indicating the lack of such procedures.

In contrast, the selected European countries demonstrate advanced levels of preparedness, characterized by comprehensive training programs, standardized safety protocols, and the use of advanced detection equipment. These countries have successfully integrated best practices into their emergency response frameworks, significantly improving their ability to manage EV-related incidents.

The implications for Kuwait are clear: adopting best practices from more advanced regions is essential to enhance the safety and effectiveness of emergency responses to EV accidents. By implementing the recommended training programs, establishing standardized protocols, and investing in specialized equipment, Kuwait can significantly improve its preparedness for the increasing adoption of EVs.

The increasing adoption of electric vehicles presents new challenges for emergency responders, particularly in handling EV-related accidents. The findings of this study underscore the urgent need for Kuwait to take proactive measures to address these challenges.

Adopting best practices from countries with advanced EV preparedness, such as Norway, Iceland, and Sweden, is crucial. Comprehensive training programs, standardized protocols, and continuous learning are essential components of a robust emergency response framework. By implementing these recommendations, Kuwait can ensure the safety of its responders and the public, ultimately leading to better outcomes in EV-related incidents.

The time for action is now. As the adoption of electric vehicles continues to rise, it is imperative for Kuwait to enhance their preparedness for EV accidents. This proactive approach will not only improve the safety and effectiveness of emergency responses but also contribute to the overall resilience of the region's emergency services. By prioritizing the safety of responders and the public, Kuwait can lead the way in establishing a safer and more sustainable future in the era of electric vehicles.

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Appendices 1

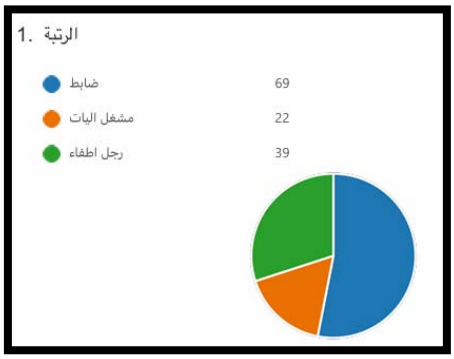
Research Survey for Readiness of the Fire Sector to Deal with Electric Vehicle Incidents (KUWAIT)

Survey Data

The survey conducted with 130 participants from the Kuwait Fire Force revealed the following key findings:

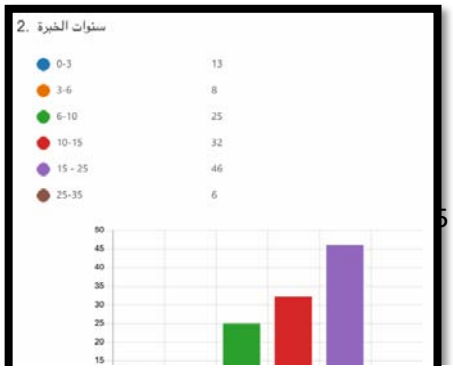
1. *Rank*

- Officer: 69
- Operator: 22
- Firefighter: 39



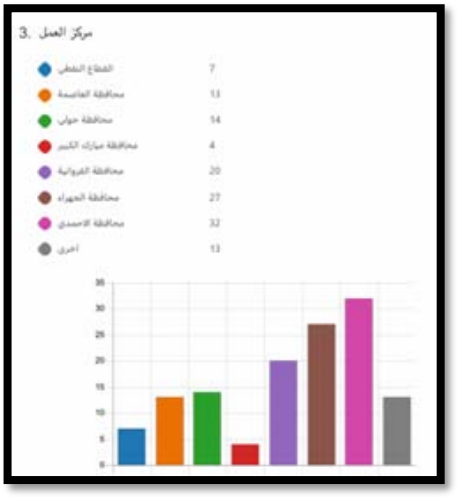
2. *Years of Experience*

- 0-3 years: 13
- 3-6 years: 8
- 6-10 years: 25
- 10-15 years: 32
- 15-25 years: 46
- 25-35 years: 6



3. *Work Location*

- Oil Sector: 7
- Capital Governorate: 13
- Hawalli Governorate: 14
- Mubarak Al-Kabeer Governorate: 20
- Farwaniya Governorate: 27
- Al-Jahra Governorate: 32
- Al-Ahmadi Governorate: 13
- Other: 13

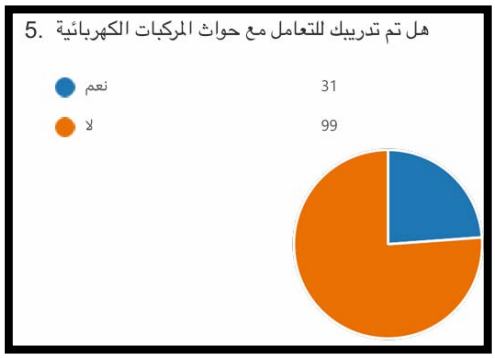


4. *Average Number of Car Accidents Handled Monthly*

- 0-5: 60
- 5-20: 54
- 20-35: 13
- 35-45: 2
- More than 45: 1

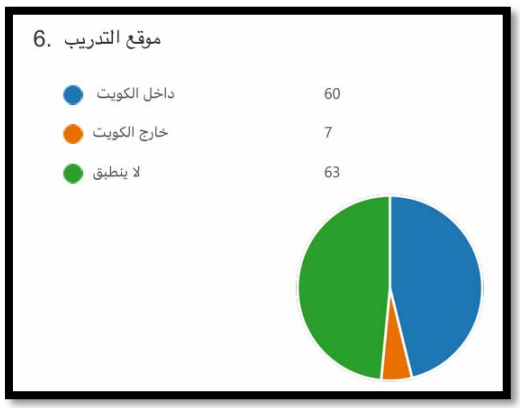
5. *Have You Been Trained to Handle Electric Vehicle Accidents?*

- Yes: 31
- No: 99



6. *Training Location*

- Within Kuwait: 60
- Outside Kuwait: 7
- Not Applicable: 63

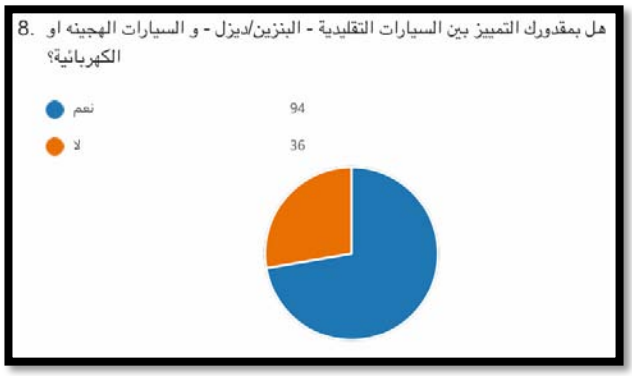


7. *Training Hours for Handling Electric Car Accidents*

- Responses: 130 – No Answer

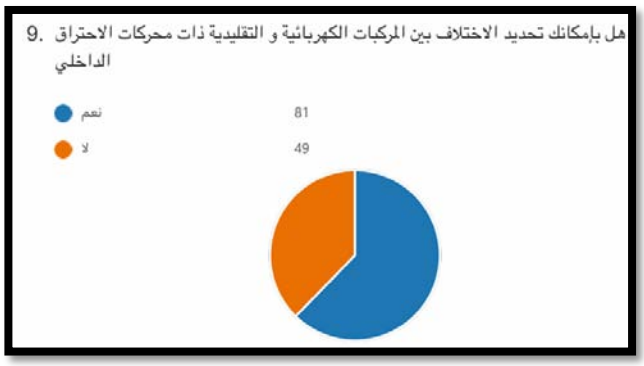
8. *Can You Distinguish Between Traditional Cars (Gasoline/Diesel) and Hybrid or Electric Cars?*

- Yes: 94
- No: 36



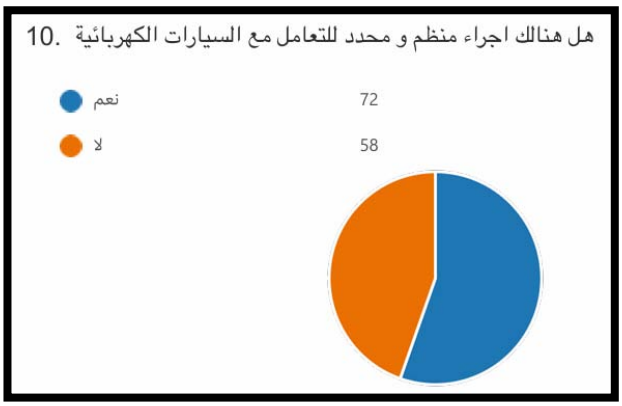
9. *Can You Identify the Difference Between Electric Vehicles and Traditional Vehicles with Internal Combustion Engines?*

- Yes: 81
- No: 49



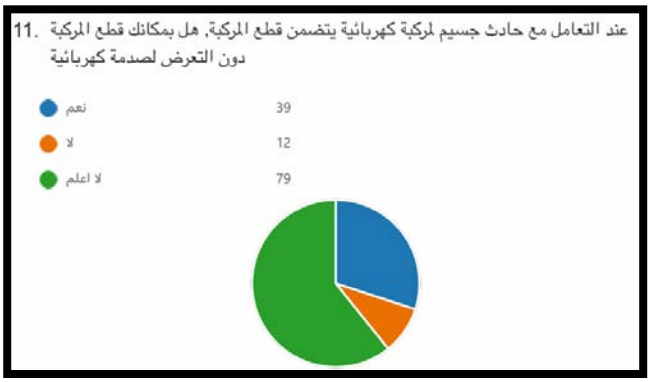
10. *Is There a Systematic and Specific Procedure for Handling Electric Cars?*

- Yes: 72
- No: 58



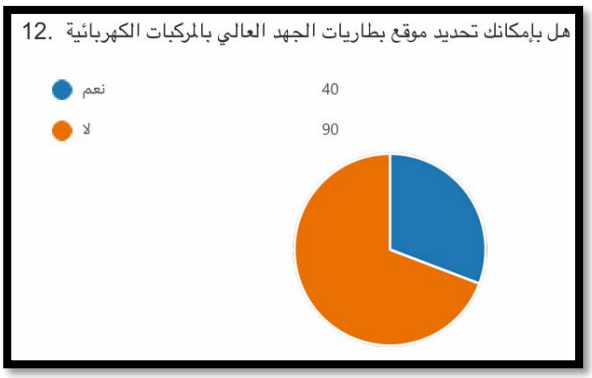
11. *When Handling a Serious Electric Vehicle Accident Involving Cutting the Vehicle, Can You Cut the Vehicle Without Exposure to Electric Shock?*

- Yes: 39
- No: 12
- Don't Know: 79



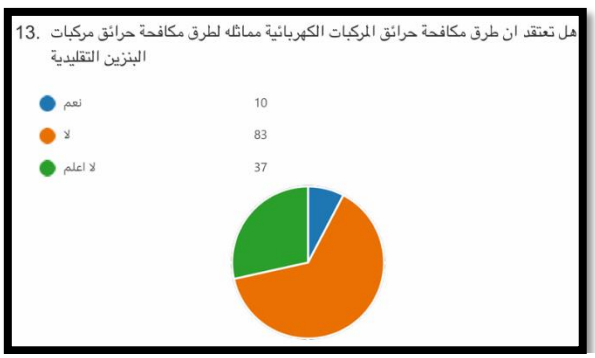
12. *Can You Identify the Location of High-Voltage Batteries in Electric Vehicles?*

- Yes: 40
- No: 90



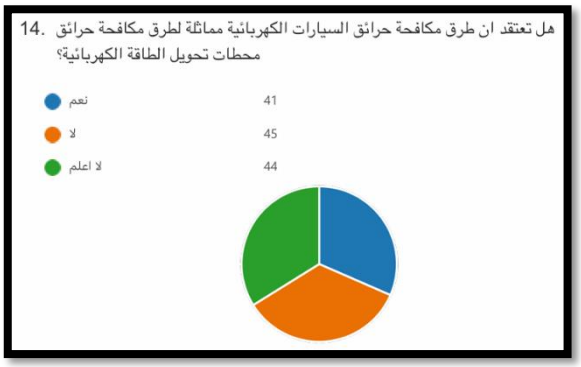
13. *Do You Think Electric Vehicle Firefighting Methods Are Similar to Traditional Gasoline Vehicle Firefighting Methods?*

- Yes: 10
- No: 83
- Don't Know: 37



14. *Do You Think Electric Vehicle Firefighting Methods Are Similar to Power Plant Firefighting Methods?*

- Yes: 41
- No: 45
- Don't Know: 44



Appendices 2

Quantitative Data Analysis Summary

The quantitative data from the survey conducted with the Kuwait Fire Force were analyzed using statistical software to identify trends and gaps in knowledge and preparedness regarding EV-related accidents. Here's a summary of the analysis:

Descriptive Statistics

Descriptive statistics were used to provide a summary of the data collected. This includes measures such as mean, median, mode, and frequency distributions.

1. *Mean:* The average value of a dataset.
2. *Median:* The middle value that separates the higher half from the lower half of the data.
3. *Mode:* The value that appears most frequently in the data set.

Inferential Statistics

Inferential statistics were applied to determine if there were significant differences between groups within the survey data. This includes tests such as chi-square tests to identify relationships between categorical variables.

1. *Chi-Square Test:* A statistical test used to examine the association between two categorical variables.

Detailed Analysis

1. *Experience Level of Respondents*
   - Mean years of experience: 13.2 years
   - Median years of experience: 15 years
   - Mode years of experience: 15-25 years
2. *Training Received for Handling EV Accidents*
   - Yes: 31 (23.8%)
   - No: 99 (76.2%)
   - The chi-square test shows a significant difference in the preparedness levels between those who have received training and those who have not ($\chi^2 = 45.67$, $p<0.05$).
3. *Ability to Distinguish Between Conventional and Electric Vehicles*
   - Yes: 94 (72.3%)
   - No: 36 (27.7%)
   - The chi-square test indicates a significant relationship between training and the ability to distinguish between vehicle types ($\chi^2 = 30.21$, $p<0.05$).
4. *Systematic and Specific Procedures for Handling EV Incidents*
   - Yes: 72 (55.4%)
   - No: 58 (44.6%)
   - The chi-square test suggests significant differences based on the work location and the presence of systematic procedures ($\chi^2 = 25.44$, $p<0.05$).

5. *Knowledge of High-Voltage Battery Locations in EVs*

- Yes: 40 (30.8%)
- No: 90 (69.2%)
- The chi-square test indicates a significant gap in knowledge regarding the location of high-voltage batteries among the respondents ($\chi^2 = 50.32$, $p<0.05$).

Interpretation of Results

The analysis reveals significant gaps in training and knowledge among the Kuwait Fire Force when it comes to handling EV-related incidents. The data indicate that:

- A majority of firefighters have not received specific training for handling EV accidents.
- Training significantly impacts the ability to distinguish between conventional and electric vehicles.
- There is a notable lack of systematic procedures for handling EV incidents, especially in certain work locations.
- Knowledge of high-voltage battery locations is limited among the respondents, posing safety risks.

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Brazil Motorcycles Categories and Hybrid Electric Technology Comparison with Powertrain Sizing

By Marcelo Fernandes De Almeida
Rio de Janeiro State University

Abstract- The world is changing and the vehicle technology is changing together to adapt to new customers behaviors, one new customer behavior is to use the electrical powertrain to traction the vehicles and decrease the transport pollution. The electrical powertrain could be detached in two groups: battery electrical vehicles (BEV), its use only an electrical engine on the vehicle, and hybrid electrical vehicle (HEV), its use the electrical engine and the internal combustion engine (ICE) together. Both are very widespread among the cars, but they do not have the same attention for the motorcycles. The BEV technology is under progress for motorcycle, while HEV has a modestly progress among the motorcycles and this study focus on this powertrain. Using the Brazil federation informs and crossing with the electrical powertrain categories definitions, this study define which motorcycle categories is adequate to use the HEV on Brazil and the powertrain specifications of these motorcycle categories.

Keywords: battery electrical vehicle (BEV), hybrid electrical vehicle (HEV), internal combustion engine (ICE), motorcycle.

GJRE-B Classification: DDC Code: 629.47 LCC Code: TL795.5

Strictly as per the compliance and regulations of:

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Marcelo Fernandes De Almeida

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Keywords: battery electrical vehicle (BEV), hybrid electrical vehicle (HEV), internal combustion engine (ICE), motorcycle.

I. Introduction

a) Motivation

New times are coming and its means we need adapt to this new times. Thinking in a new world and in the future, the mobility is changing to adapt to new mindset and be healthier.

One of the contributor to pollution is the ICE (internal combustion engine), present in each city in the world, the ICE operation spread a lot of particles in the air and increase the pollution on the cities. According IEA report 2017, "transport sector alone contributes to 24% of CO2 emissions in 2015".

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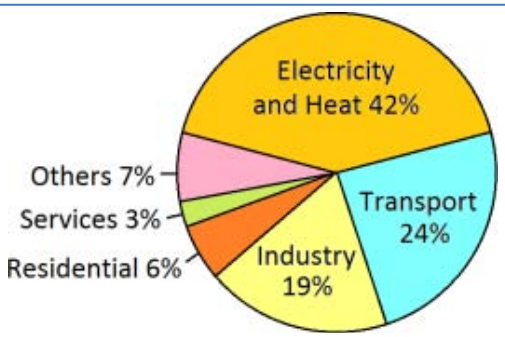

Figure 1: World CO2 Emissions from Fuel Combustion by Sector (IEA Report 2017)

The internal combustion engine was a huge step to society development and their evolution, but to achieve new targets with new mindset, the society are looking to be healthy. To achieve this new healthy target, we are walking to new technologies to decrease the pollution emissions from the transports, as the BEV (Battery Electric vehicles) and the HEV (hybrid electric vehicles).

i. *BEV Definition*

According Vidyanandan (2018), "Battery electric vehicles are propelled by electric motors by using energy stored on board in batteries". Therefore, BEV vehicles does not have a presence of the ICE to help the propulsion system. Basic, the BEV has the Battery, Engine and the Transmission

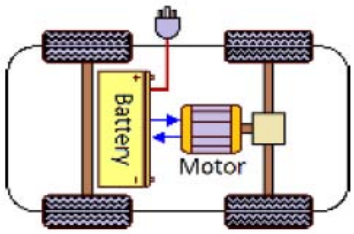

Figure 2: Basic BEV System (Vidyanandan, 2018)

ii. *HEV Definition*

HEV (Hybrid vehicles) have the internal combustion engine with the electric engine and, according Vidyanandan (2018), "Hybrid electric vehicles

have the benefits of both ICE vehicles and electric vehicles, and overcome their individual disadvantages".

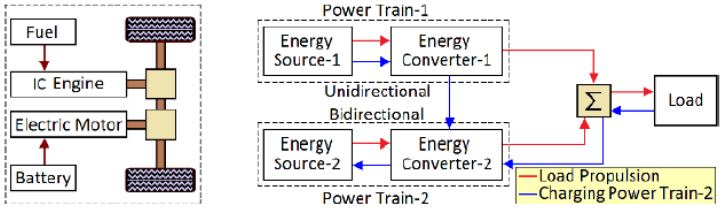

Figure 3: Arrangement of a HEV with Power Flow Paths(Vidyanandan, 2018)

For cars, the BEV or HEV technology are very solid and society has many examples used by the world-renowned brands as:

BEV: BMW i3 (BEV), Nissan Leaf, Chevrolet Bolt, Audi e-Tron and Renault Zoe;

HEV: Toyota Prius, Audi A7 Sportback, Ford Fusion Hybrid, BMW i3 (HEV), Volvo XC60 and many others.

However, the motorcycles category does not have the same scenario for both. The motorcycle world-renowned brands do not have the same presence of BEV or HEV and between both technologies have a difference, the companies have more BEV in comparison than HEV as.

BEV: Voltz EV01, Aima Tiger X6, MUUV Custom S, Magias Italiane Maranello and Energie Mobi Super Soco TC;

HEV: Honda PCX.

In addition, these BEV motorcycles have a low autonomy, being common to have between 60 and 80km.

b) Main Goals

Knowing about the motorcycle technology opportunity for electric vehicle with large area to explore, this present article have as main goals:

- Identify the Brazilian motorcycle customer behavior;
- Identify the best match motorcycle for HEV;
- Define the specifications to sizing the hybrid engine.

II. Comparison between BEV x HEV x ICE

According Vidyanandan (2018), the main difference between BEV and the HEV vehicle is the autonomy. BEV is better when the customer need to drive low distances and do not use the vehicle to travel, otherwise is better use the HEV for long distances.

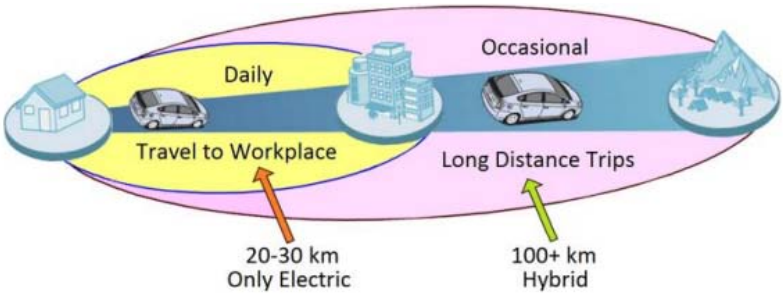

Figure 4: Travel Range of a Typical PHEV in Different Modes (Vidyanandan, 2018)

Mass comparison between ICE x HEV x BEV

Table 1: Mass comparison ICE x BEV x HEV(Sources: Fiat Italy website; Volkswagen Portugal website; Peugeot UK website; Jac China website; Toyota USA website; Mitsubishi North America website; Nissan Japan website; Car and Drive website)

Vehicle	ICE	HEV	BEV	Difference BEV - ICE	Difference HEV - ICE	Difference BEV - HEV
Fiat 500	Rockstar ICE 930 kg	500 Hybrid HEV 980 kg	500e BEV 1351 kg	+421 kg	+50 kg	+371 kg
Volkswagen Golf	Golf 115CV 200Nm ICE 1240 kg		E-Golf 136CV BEV 1615 kg	+375 kg		
Volkswagen up	up 65CV 91Nm ICE 991 kg		e-up 83CV BEV 1235 kg	+244 kg		
Peugeot 208	1220cm³ turbo ICE 1158 kg		136HP 260Nm BEV 1455 kg	+297 kg		
Jac S2 (IEV7S)	112HP 146Nm ICE 1110 kg		270Nm BEV 1495 kg	+385 kg		
Toyota Camry	2.5L 203HP 203HP ICE 1470 kg	2.5L 208HP 149Nm HEV 1610 kg			+140 kg	
Toyota Avalon	205HP 163lbft ICE 1620 kg	215HP 149lbft HEV 1640 kg			+20 kg	
Mitsubishi Outlander	166HP 220Nm ICE 1510 kg	80kW per engine 195Nm HEV 1915 kg			+405 kg	
Nissan Note	142Nm ICE 1090 kg	e-Power 254Nm HEV 1230 kg			+140 kg	
BMW i3		BMW i3 181HP 199Nm HEV 1500 kg	181HP 199Nm BEV 1379 kg			-121 kg

Using the last information, we can define the table below:

Table 2: Categories Main Points

Powertrain	Main points
ICE	Highest in CO2 emission in comparison than HEV / BEV
	High autonomy
	Lighter vehicle in comparison than HEV / BEV
	Quickly fuel (Easy for travels)
HEV	Low CO2 emission

	High autonomy
	Little heaviest
	Quickly fuel (Easy for travels)
BEV	No CO2 emission due to engine
	Low autonomy
	Heaviest than ICE and HEV
	Lengthy fuel

III. Brazilian Motorcycle Categories

According Izo (2019), Brazil has the bellow main motorcycle categories:

Scooter: Scooter has 50cm³ to 150cm³ and aimed at younger customers. Normally, the gearbox is automatic; you have a good driveability inside the cities and have a pocket to keep small things. Scooters does not have the same comfort & safety than the biggest motorcycles and the pilot drive in the sitting position.

Figure 5: Scooter: Yamaha Nmax 160 (Izo, 2019)

Cub: Looks like scooters, but the pilot have a foot pegs to put your feet. The fuel economy is this motorcycle spotlight.

Figure 6: Cub: Honda Biz 125 2018 (Izo, 2019)

Sport: Sport motorcycles were created for strong accelerations. However, this motorcycle do not have a comfortable seat due to design made to optimize the aerodynamic (pilot must to put his chest close the tank to increase the aerodynamic). The suspension is very rigid and the seat usually is uncomfortable. This motorcycle can achieve easily 1200cm³.

Figure 7: Sport: Honda Cbr 1000rr Fireblade (Izo, 2019)

Naked: The customers usually drive in the cities or highways. Naked motorcycles have few fairing, only the necessary. This motorcycle has a large range of sizes (200cm³ - 1000cm³).

Figure 8: Naked: YAMAHA MT-07 ABS 2019 (Izo, 2019)

Custom: Made for roadways. Design for pilot comfort with low seat, long suspensions and high handlebar. Normally have a range of sizes (800cm³ - 1000cm³).

Figure 9: Custo: Harley-Davidson Sportster 883 2018 (Izo, 2019)

Trail: Tall motorcycle with tall seat, suspension and handlebar. Trail motorcycle has a good driveability for city and travels. Normally the customer drive in different roads (dust, asphalt and others). Displacement average close the 1000cm³.

Figure 10: Trail: Triumph Tiger 800 Xrx (Izo, 2019)

Below the table with the motorcycle categories description:

Table 3: Categories Main Points

Category	Main points
Scooter	City usage
	Young customers
	Low displacement (50cm³ - 150cm³)
	Economic
	Uncomfortable (Drive in sitting position)
Cub	City usage
	Young customers
	Low displacement (100cm³ - 125cm³)
	Economic
	Average comfortable (Drive with foot pegs)
Sport	Sport usage
	"Sport" customers
	High displacement (as 1200cm³)
	High consumption
	Uncomfortable
Naked	City / highway usage
	Large range of customers
	Large range of displacement (200cm³ - 1000cm³)

	Large range of consumption
	Average comfort
Custom	Highway / Travel usage
	Traveling Customers
	High displacement (until 1800cm³)
	Average to high consumption
	Very comfortable
Trail	City / Travel / Trail usage
	Daily usage with some travels
	High displacement (average of 1000cm³)
	Average to high consumption
	Comfortable

IV. Comparison between Motorcycle and Powertrains

Below the table crossing the information from motorcycles categories and the engine types:

Table 4: Comparison Between Categories and Engines

	ICEV Highest in CO2 emission in comparison than HEV / BEV High autonomy Lighter vehicle in comparison than HEV / BEV Quickly fuel (Easy for travels)	HEV Low CO2 emission High autonomy Little heaviest Quickly fuel (Easy for travels)	BEV No CO2 emission due to engine Low autonomy Heaviest than ICE and HEV Lengthy fuel
Scooter City usage Young customers Low displacement (50cm³ - 150cm³) Economic Uncomfortable (Drive in sitting position)	3	2	1
Cub City usage Young customers Low displacement (100cm³ - 125cm³) Economic Average comfortable (Drive with foot pegs)	3	2	1
Sport Sport usage “Sport” customers	1	3	2

High displacement (as 1200cm³) High consumption Uncomfortable			
Naked City / highway usage Large range of customers Large range of displacement (200cm³ - 1000cm³) Large range of consumption Average comfort	1	2	3
Custom Highway / Travel usage Traveling Customers High displacement (until 1800cm³) Average to high consumption Very comfortable	2	1	3
Trail and Big Trail City / Travel / Trail usage Daily usage with some travels High displacement (average of 1000cm³) Average to high consumption Comfortable	2	1	3

According the table, Custom and Trail are the most compatible motorcycle categories with HEV technology because they are used to long travels, needed a quickly fuel, high autonomy and use to decrease the pollution.

V. Specification for Custom and Trail

Fenabrave is a national automotive federation from Brazil and the best in class motorcycle for each category could be identify through the Fenabrave informs. Below the Fenabrave informs ranking table from December 2019 for Trail motorcycles and Customs:

Maxtrail

	Modelo	2019 Nov	2019 Dez		2019 Acumulado	Part.
1°	TRIUMPH/TIGER 800	193	316	▲	2.837	20,07%
2°	BMW/F850 GS	166	226	▲	2.134	15,09%
3°	BMW/R1250GS	326	340	▲	1.900	13,44%
4°	BMW/R1200	3	5	▲	1.431	10,12%
5°	TRIUMPH/TIGER 1200	62	77	▲	917	6,49%
6°	SUZUKI/VSTROM650	102	113	▲	899	6,36%
7°	ROYAL ENFIELD/HIMALAYA	77	118	▲	805	5,69%
8°	BMW/F750 GS	63	105	▲	731	5,17%
9°	KAWASAKI/VERSYS	84	82	▼	652	4,61%
10°	HONDA/CRF 1000L	44	36	▼	337	2,38%
	Total	1.229	1.513	▲	14.139	100%

Custom

	Modelo	2019 Nov	2019 Dez		2019 Acumulado	Part.
1°	H.DAVIDSON/FL FB	44	79	▲	820	10,86%
2°	KAWASAKI/VULCAN S	89	75	▼	820	10,86%
3°	H.DAVIDSON/XL 883	134	91	▼	745	9,87%
4°	H.DAVIDSON/XL 1200	16	37	▲	546	7,23%
5°	ROYAL ENFIELD/CLASSIC	43	43	=	537	7,11%
6°	H.DAVIDSON/FXFB	24	44	▲	498	6,60%
7°	H.DAVIDSON/FL FBS	25	36	▲	461	6,11%
8°	TRIUMPH/BONNEVILLE	43	39	▼	373	4,94%
9°	H.DAVIDSON/FX FBS	46	52	▲	367	4,86%
10°	H.DAVIDSON/FL SB	10	10	=	303	4,01%
	Total	648	742	▲	7.548	100%

Figure 11: Ranking Fenabrave December 2019 (Fenabrave, 2020)

Based on the sales ranking from Fenabre, the best sales motorcycles specification will be used to define the motorcycles specification target.

Table 5: Specification table (Sources: Triumph Brazil website; BMW Brazil website; Suzuki Brazil website; Harley Davidson Brazil website; Kawazaki Brazil website; Royal Enfield Brazil website)

Motorcycle	Torque	Power	Energy	Mass
Triumph / Tiger800	79 Nm (8,0 kgf.m) @ 7,850 rpm	95 CV @ 9,250 rpm	70 kW @ 9,250 rpm	199 kg
BMW / F850 GS	88 Nm (9,0 kgf.m) @ 6,250rpm	80 CV @ 6,250 rpm	58 kW @ 6,250 rpm	229 kg
BMW / R1250GS	143 Nm (14,6 kgf.m) @ 6,250 rpm	136 CV @ 7,750 rpm	100 kW @ 7,750 rpm	249 kg
BMW / R1200	125 Nm (12,7 kgf.m) @ 6,500 rpm	92 CV @ 7,750 rpm	92 kW @ 7,750 rpm	232 kg
Triumph / Tiger 1200	122 Nm (12,4 kgf.m) @ 7,600rpm	141 CV @ 9,350 rpm	104 kW @ 9,350 rpm	242 kg
Suzuki / Vstrom650	62 Nm (6,32 kgf.m) @ 6,500RPM	71 CV @ 8,800 rpm	52 kW @ 8,800 rpm	199 kg
H.Davison / FL FB	145 Nm (14,8 kgf.m) @ 3,000 rpm	71 CV @ 4,560 rpm	52 kW @ 4,560 rpm	304 kg
Kawazaki / Vulcan S	63 Nm (6,4 kgf.m) @ 6,600 rpm	61 CV @ 7,500 rpm	45 kW @ 7,500 rpm	228 kg
H.Davison / XL 883	68 Nm (6,9 kgf.m) @ 4,750 rpm	52 CV @ 5,750 rpm	38 kW @ 5,750 rpm	247 kg
H.Davison / XL 1200	96 Nm (9,8 kgf.m) @ 3,500 rpm	66 CV @ 6,000 rpm	49 kW @ 6,000 rpm	248 kg
Royal enfield / Classic	52 Nm (5,3 kgf.m) @ 5,250 rpm	47 CV @ 7,250 rpm	35 kW @ 7,250 rpm	202 kg

Follow the train of thought, below the specification comparison and the analysis to define the targets for Custom and Trail motorcycle categories.

Table 6: Motorcycle Categories Analysis

Motorcycle	Peso	Torque	Torque / kg	Torque/kg variation (Unid / Cat average)
Triumph / Tiger800	199 kg	79 Nm	0,40 Nm/kg	-12%
BMW / F850 GS	229 kg	88 Nm	0,38 Nm/kg	-15%
BMW / R1250GS	249 kg	143 Nm	0,57 Nm/kg	27%
BMW / R1200	232 kg	125 Nm	0,54 Nm/kg	19%
Triumph / Tiger 1200	242 kg	122 Nm	0,50 Nm/kg	12%
Suzuki / Vstrom650	199 kg	62 Nm	0,31 Nm/kg	-31%
H.Davison / FL FB	304 kg	145 Nm	0,48 Nm/kg	43%
Kawazaki / Vulcan S	228 kg	63 Nm	0,28 Nm/kg	-17%
H.Davison / XL 883	247 kg	68 Nm	0,28 Nm/kg	-18%
H.Davison / XL 1200	248 kg	96 Nm	0,39 Nm/kg	16%
Royal enfield / Classic	202 kg	52 Nm	0,26 Nm/kg	-23%
Average MaxTrail	**225 kg**	**103 Nm**	**0,45 Nm/kg**	
Min MaxTrail	**199 kg**	**62 Nm**	**0,31 Nm/kg**	
Max MaxTrail	**249 kg**	**143 Nm**	**0,57 Nm/kg**	
Average Custom	**246 kg**	**85 Nm**	**0,33 Nm/kg**	
Min Custom	**202 kg**	**52 Nm**	**0,26 Nm/kg**	
Max Custom	**304 kg**	**145 Nm**	**0,48 Nm/kg**	
Geral Average	**234 kg**	**95 Nm**	**0,40 Nm/kg**	

According the Table 6. Motorcycle categories analysis, the Trail specifications are:

Weight: Average of 225kg, range between 199Kg and 249Kg;

Torque: Average of 103Nm, range between 62Nm and 143Nm;

Correlation between torque and weight: Average of 0,45Nm/Kg, range between 0,31Nm/kg and 0,57Nm/Kg. And the Custom specification are:

Weight: Average of 246kg, range between 202Kg and 304Kg;

Torque: Average of 85Nm, range between 52Nm and 145Nm;

Correlation between torque and weight: Average of 0,33Nm/Kg, range between 0,26Nm/kg and 0,48Nm/Kg.

VI. Conclusion

According to these work data, the motorcycle categories with best match to hybrid electric vehicle (HEV) technology are Custom and Trail motorcycle categories due the necessities to do travels and, consequently, need more autonomy and a quickly fuel.

Need to consider some points to design the HEV powertrain for motorcycle. Following these work analysis:

- Correlation between torque and weight is important because it demonstrates how much torque the motorcycle needs to meet the customer's behavior;
- Weight demonstrate the range of mass the motorcycle could be to meet the customer's behavior.

For example, the trail motorcycles customer drives in different roads and some roads, as dirt or bumpy roads, the customer need a lighter and taller motorcycle with high torque (as 0,45Nm/Kg), in comparison the custom motorcycle customer basically use on asphalt and needs a heaviest and lower motorcycle with a reasonable torque (0,33Nm/Kg). Therefore, the trail motorcycle must be lighter than custom motorcycle and, normally, the trail motorcycle has more torque than custom motorcycle.

In addition, considering the analysis, the good motorcycle target to apply HEV technology is:

- Trail motorcycles: Triumph/Tiger800 is the motorcycle close the average with 0,40Nm/kg against the average of 0,45Nm/kg and this is the best-selling motorcycle for Trail category;
- Custom motorcycles: H.Davison/XL883 is the motorcycle close the average with 0,28Nm/kg against the average of 0,33Nm/kg and H.Davison is the brand best-selling motorcycles for Custom categories;

Abbreviations:

ICE – Internal combustion engine
HEV – Hybrid electrical vehicle
BEV – Battery electrical vehicle

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Computational Study of Turbulence and Recirculation Effects in Turbine Blade Cooling Channel

By J. Alrajhi

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Keywords: *flow, turbine, blade, cooling, passage, turbulence modeling, gas turbine.*

GJRE-B Classification: *LCC: TL210*

Strictly as per the compliance and regulations of:

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Keywords: flow, turbine, blade, cooling, passage, turbulence modeling, gas turbine.

I. Introduction

Cooling turbine blades is crucial in gas turbine engines, which endure high thermal stresses. Implementing efficient cooling techniques is vital to preserve blade integrity and optimize engine performance. Several methods are utilized to improve heat transfer rates within the cooling channels of turbine blades and combustion chamber liners. These methods include ribbed turbulators, pin fins, jet impingement cooling, dimpled surfaces, rough surfaces, protruding elements, various turbulence enhancers, and swirl chambers. These features boost secondary flows and turbulence, thereby enhancing mixing and convective heat transfer rates with minimal additional pressure loss. However, the interior air cooling system, which removes heat from the internal surfaces of the blade, faces the significant challenge of increased pressure losses due to the turbulent flow required for effective heat transfer.

II. Literature Review

Bredberg and Davidson (2002) conducted a computational study on a turbulator-enhanced U-bend at a high Reynolds number (Re = 95000), discovering that heat transfer improves downstream of the bend due to elevated turbulence levels. Saidi and Sunden (2000) performed numerical predictions of fluid flow and heat transfer in ducts with ribbed walls using a low Reynolds number turbulence model, concluding that while the turbulators improved heat transfer, they also considerably increased the friction factor or pressure losses. Yang and Hwang (2004) investigated heat transfer and fluid flow characteristics in rectangular ducts with slit and solid turbulators, finding that the friction factor for the slit-ribbed duct is lower than that for the solid-ribbed duct and decreases as the turbulator void fraction increases. Recent research by Gao et al. (2021) demonstrated notable improvements in heat transfer and pressure drop characteristics with innovative turbulator geometries.

Yang and Hwang devised and utilized a turbulent model to examine "heat transfer and fluid flow characteristics in rectangular ducts with slit and solid turbulators mounted on one wall." They discovered that the friction factor for the slit-ribbed duct is lower than that for the solid-ribbed duct and decreases as the turbulator void fraction increases. Korichi and Oufer conducted a computational investigation in a rectangular channel with heated obstacles alternately mounted on the upper and lower walls, assuming time-dependent two-dimensional flow with constant thermophysical properties for air at three Reynolds numbers (50, 500, and 1000).

Iacovides and colleagues examined the flow development through an orthogonally rotating U-bend with ribbed walls, emphasizing the complex flow patterns and turbulence characteristics that influence heat transfer. Their research highlighted the significance of turbulence promoters in boosting cooling efficiency within turbine blades.

Recent research has continued to explore these areas, with new advancements in computational fluid dynamics (CFD) models and experimental techniques. Gao et al. investigated the impact of innovative turbulator geometries on heat transfer and pressure drop characteristics, demonstrating notable improvements in performance over conventional designs.

By incorporating these recent studies, our research aims to enhance the understanding of fluid flow dynamics in turbine blade cooling channels, with a particular focus on the performance of rectangular turbulators. Furthermore, Smith and colleagues introduced advanced turbulence modeling techniques that yield more accurate predictions of flow behavior in

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intricate duct geometries. By integrating these recent studies, our research seeks to contribute to the comprehension of fluid flow dynamics in turbine blade cooling channels, specifically concentrating on the effectiveness of rectangular turbulators.

III. Methodology

Sixteen rectangular turbulators are modeled in a sharp 180° U-turn tube, with eight turbulators on each side. The tube has a width d with a 180° bend of a mean radius rc/dr equal to 0.65. The turbulator-height to duct-diameter ratio h/d is 0.15, the turbulator-height to width h/w is 1.5, and the spacing to duct-diameter ratio S/d is 1. The turbulators are distributed on both walls in a staggered arrangement. The turbulators closest to the bend are at 0.45dfrom the bend entry and exit. The distance from the inlet and outlet to the first and last turbulator, respectively, is 3.5d.

The mesh or grid is a structured type cell (Quad cell) generated in Gambit, with 68,930 quadrilateral cells uniformly distributed across the geometry. The boundary conditions set the walls using the standard wall function with a no-slip condition. The outlet is set as a pressure outlet, while the inlet is set as a velocity inlet normal to the boundary, with the velocity in the y-direction being zero and the x-direction velocity set at 10 m/s.

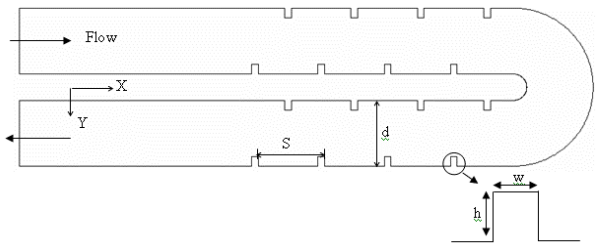

Figure 1: The geometry of the vertical rectangle turbulator case

IV. Results and Discussion

The velocity profiles for the entire geometry, including the turbulators, are shown in Figure 2. The width of eddies is larger in the rectangular turbulator compared to the square turbulator shown in Bredberg and Davidson's study. Negative x-velocity values appear between the turbulators and decrease as the flow approaches the bend. At the last turbulator on each wall side, the negative x-velocity values increase, creating very large eddies at the upper wall of the bend.

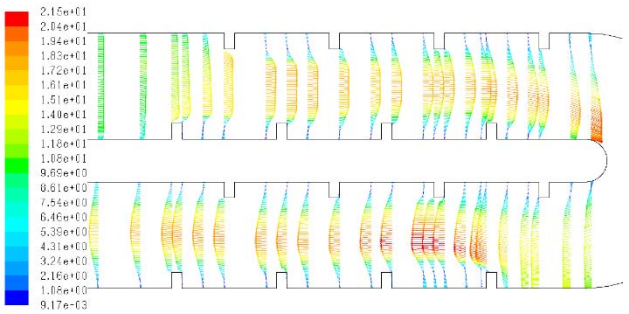

Figure 2: Velocity vectors profile for vertical rectangle turbulator case

The eddies in the bend reduce the diameter, allowing the air to flow and increasing the velocity to a maximum inside the turn. The flow proceeds towards the opening in the tube downstream. The flow cannot follow the curve downstream of the turn, creating an eddy near the upper wall before the first turbulator downstream. Between the second and fourth turbulators on the lower wall downstream, a large eddy forms, reducing the mainstream area and increasing the velocity in the middle of the duct to satisfy the continuity equation. After the last turbulator, a large recirculation is formed with a size almost equal to 3h.

Figures 3 to 6 show the velocity vectors of the four parts of the geometry with fixed-length vectors indicating low-velocity regions. Figure 3 shows the first part upstream, which includes the first six turbulators. Separation starts from a distance equal to half of the turbulator height (h) before the turbulator and does not reattach before the second turbulator for the first three turbulators. Large eddies are created just after the last upper turbulator, covering half of the bend's outer distance. At the last bottom turbulator upstream, recirculation is reduced in size due to the high-velocity region moving towards the lower wall to enter the downstream tube opening.

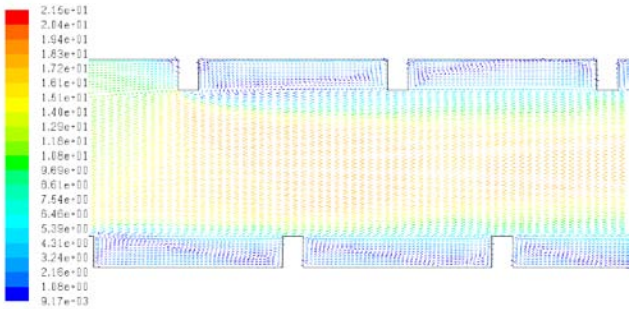

Figure 3: Velocity vectors for first turbulators upstream the u-turn for vertical rectangle turbulator case

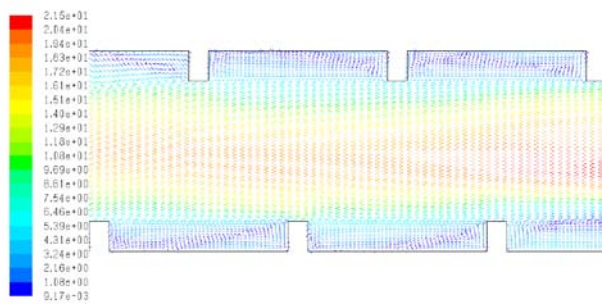

Figure 4: Velocity vectors for last turbulators upstream the u-turn for vertical rectangle turbulator case

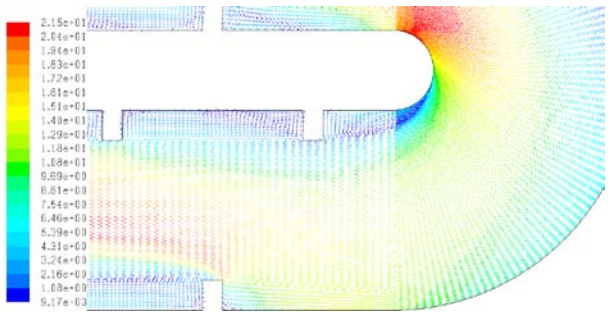

Figure 5: Velocity vectors for first turbulators downstream the u-turn for vertical rectangle turbulator case

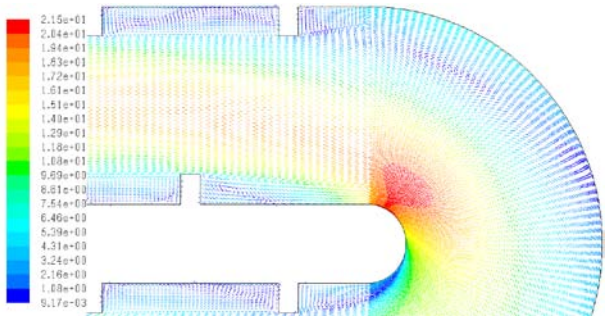

Figure 6: Velocity vectors for last turbulators upstream the u-turn for vertical rectangle turbulator case

Following the intricate flow patterns observed in our numerical simulations, it becomes evident that further investigations are warranted to explore the underlying mechanisms driving these phenomena. The formation and dissipation of eddies within the turbine blade cooling passages represent complex fluid dynamics phenomena influenced by various factors, including geometrical configurations, flow velocities, and turbulence intensities. Future research endeavors could leverage advanced computational techniques, such as large-eddy simulation (LES) or direct numerical simulation (DNS), to capture finer details of turbulent structures and their interactions with turbulators and curved geometries. Additionally, experimental studies utilizing state-of-the-art measurement techniques, such as particle image velocimetry (PIV) or hot-wire anemometry, could provide valuable validation data to enhance the accuracy and reliability of numerical predictions.

Moreover, it is crucial to extend our analysis beyond two-dimensional models and explore the three-dimensional aspects of fluid flow in turbine blade cooling channels. While our study offers valuable insights into the flow behavior within a simplified geometry, real-world turbine blade passages often exhibit more complex geometrical features and three-dimensional flow phenomena. By incorporating three-dimensional effects into our numerical models and experimental investigations, we can gain a more comprehensive understanding of flow physics and turbulence characteristics, enabling more accurate predictions and informed design decisions for turbine cooling systems. This holistic approach, encompassing both numerical simulations and experimental validations, holds the key to unlocking the full potential of turbine blade cooling technologies and advancing the efficiency and reliability of modern gas turbine engines.

Unlike the square turbulator case, small recirculation appears before the first turbulator. A large eddy in both directions is placed between the second and fourth turbulators on the lower wall side. The flow separates before the second turbulator and reattaches behind the fourth turbulator due to centrifugal forces in the bend and another force with its center between the second and fourth turbulators downstream of the turn. The recirculation region sizes behind the rest of the turbulators show similar behaviors, with large recirculation after each turbulator immediately separating before the next turbulator.

Continuing our exploration, it is imperative to consider the influence of operational parameters and environmental conditions on the performance of turbine blade cooling systems. Factors such as inlet air temperature, coolant flow rate, and ambient pressure can significantly impact the heat transfer efficiency and overall effectiveness of cooling strategies. Future studies could investigate the transient behavior of cooling flows under varying operating conditions, simulating realistic scenarios encountered during turbine operation. Furthermore, the integration of advanced materials and coatings tailored to withstand high-temperature environments and corrosive gasses presents a promising avenue for enhancing the durability and longevity of turbine components. By incorporating these factors into our analyses, we can develop robust cooling solutions that not only optimize thermal performance but also ensure the reliability and safety of turbine systems in demanding operational environments.

Figure 7 shows the velocity magnitude contours for the entire geometry. The turbulator height is larger than in the square turbulator case, reducing the distance between the heads of each two turbulators to 0.7ddd. This causes the velocity to increase in the middle to compensate for the reduced flow area and satisfy the continuity equation.

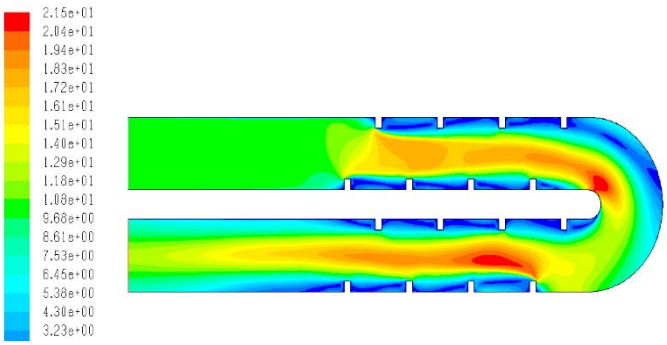

Figure 7: Velocity magnitude contours for vertical rectangle turbulator case

V. Conclusion

Our study highlights the crucial role of interdisciplinary collaboration in addressing complex engineering challenges. By developing advanced computational fluid dynamics (CFD) models and complementing them with experimental validation, we can achieve a deep understanding of the intricate phenomena occurring within turbine blade cooling passages. Integrating insights from fluid dynamics, heat transfer theory, and turbomachinery design enables us to create innovative solutions that enhance cooling performance while minimizing energy losses and operational costs.

Recognizing the limitations of our study is essential, as it provides direction for future research. While our numerical model offers valuable insights, there is significant potential for refinement through experimental testing and field measurements. Additionally, the effects of varying operating conditions, such as different Reynolds numbers, turbulence intensity, and coolant properties, require further exploration. By addressing these challenges, future research can continue to advance turbine blade cooling technology, ultimately leading to more efficient and sustainable power generation systems.

Future research should focus on developing adaptive cooling strategies that respond to real-time changes in operating conditions. Implementing these strategies involves integrating advanced sensors and control systems within turbine engines, allowing for dynamic adjustment of cooling parameters to optimize performance. This approach could yield significant improvements in both the efficiency and longevity of turbine components.

Moreover, collaboration with materials scientists can drive the creation of innovative cooling channel designs and materials. By leveraging new manufacturing techniques, such as additive manufacturing, it is possible to develop complex cooling geometries that were previously unattainable. These advancements can lead to more effective heat transfer and improved thermal management, enhancing the overall performance and sustainability of gas turbine engines.

In conclusion, our research underscores the importance of combining advanced computational models with experimental validation and interdisciplinary collaboration. By addressing the current limitations and exploring new technologies, we can significantly improve turbine blade cooling systems, contributing to the efficiency and sustainability of modern gas turbine engines.

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j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

Tips for Writing a Good Quality Engineering Research Paper

Techniques for writing a good quality engineering research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of research engineering then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.

- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

Criterion for Grading a Research Paper (Compilation) by Global Journals

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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