Optimizing Structural Integrity in Tank Mount Components: Electrical Testing for Advanced Breakage Prevention

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Abstract
This paper examines the implementation of a breakpoint for tank mount components, specifically setting it at a minimum of 77 lbF to mitigate breakage during assembly processes. This strategic decision resulted in a zero percent failure rate during assembly at client locations. The paper discusses the methodology, results, and implications of this approach, supported by relevant literature published. Notably, the study also evaluates the application of polypropylene as a material for tank mount parts.

Keywords: Breakpoint settings, tank mount parts, polypropylene, mechanical failure, assembly process, stress testing, material strength

Introduction
Tank mount parts are essential in various mechanical systems, ranging from industrial machinery to automotive and consumer product applications. The durability and integrity of these components are crucial in preventing operational failures that can disrupt production, increase costs, and introduce potential safety hazards. Failures during the assembly of tank mount parts, in particular, can be attributed to inadequate breakpoint settings, leading to premature material failure.
This study explores the process of establishing a specific breakpoint threshold for tank mount parts, setting it at a minimum of 77 lbF (35 kgF). The goal is to enhance the structural resilience of these components, thereby preventing breakage during the assembly process. The study's findings have broad implications for industries relying on tank mount components and contribute to the growing body of knowledge regarding optimal material selection and breakpoint determination.

Importance of Breakpoint Settings
In my role at the Plastic Injection Molding facility, understanding the importance of setting an appropriate breakpoint became a pivotal factor in improving part reliability. The concept is simple—every part has a force threshold at which it will fail—but determining the right breakpoint requires careful testing and real-world validation. Through my hands-on work, I found that parts with breakpoints below 77 lbF were consistently failing at customer sites during the actual installation into tanks. These parts passed initial inspections in-house but couldn't handle the stress exerted during installation. The failures resulted in downtime for our clients, operational inefficiencies, and the potential for serious reputational damage.
Recognizing the severity of this issue, I implemented a structured approach to stress testing. By analyzing historical failure data and conducting a series of tests, we determined that setting the breakpoint at a minimum of 77 lbF drastically improved the durability of the tank mount parts. Once this breakpoint was introduced, the failures at client locations ceased entirely, reinforcing the idea that a well-defined breakpoint is critical for preventing part failure in real-world applications.

Beyond just the breakpoint setting, we conducted an extensive study on the use of regrind materials in the production process. Regrind usage can significantly impact the mechanical properties of the parts, so we ran several Design of Experiments (DOEs) by adding 25%, 50%, and 75% regrind to the production process. Through these trials, we discovered that adding 25% regrind gave us the best overall part strength. After determining that 25% was the optimal regrind ratio, we fixed that constant and shifted our focus to optimizing the rest of the process parameters.

I conducted a series of additional process DOEs, adjusting barrel temperatures, nozzle temperatures, plastic melt temperatures, injection velocities, injection pressures, injection times, cooling times, and other critical parameters. By systematically testing these factors, we created a robust process that consistently produced parts with the best strength and durability. This combination of carefully controlled regrind usage and optimized process parameters allowed us to strike the right balance between material efficiency and part performance, ensuring that our tank mount parts could meet both cost and quality expectations.

The success of these studies highlights how critical it is to not only set an appropriate breakpoint but to also fine-tune every aspect of the production process. By doing so, we ensured that our parts could withstand real-world stresses, improving reliability and customer satisfaction. This iterative, data-driven approach is now an integral part of how we approach new challenges in production, continually refining our processes to meet the highest standards.

Background

Mechanisms of Breakage

Mechanical breakage can occur due to several factors, including inadequate material strength, improper assembly techniques, and unforeseen stress concentrations. These factors often intersect, creating weak points in a component that ultimately lead to failure. Research by Caldwell (2018) indicates that an in-depth understanding of these factors allows for more effective preventative strategies.

Stress concentrations, such as those around sharp corners, notches, or holes in mechanical parts, are particularly problematic. Lee, Kim, and Park (2016) note that such discontinuities in a component's geometry can drastically reduce its ability to withstand stress, leading to premature breakage. By analyzing these weak points, engineers can optimize designs to reduce the likelihood of failure.

Historical Context

Historically, mechanical component failures during assembly have been a persistent issue across multiple industries. Prior to implementing robust breakpoint settings, some companies reported failure rates exceeding 10% during assembly processes (Davis & Miller, 2018). These failures caused significant operational delays, increased costs, and even safety risks for workers and consumers. The industry's growing emphasis on product reliability and safety has led to the increased focus on accurate breakpoint determination as part of the engineering design process.

Polypropylene as a Material

Polypropylene (PP) is widely regarded for its versatility and mechanical properties. This thermoplastic polymer is known for its flexibility, strength, chemical resistance, and low density, making it suitable for various industrial applications. Yuan, Yang, and Zhang (2018) discuss the benefits of using polypropylene in the context of tank mount components, where the material's durability and resistance to environmental factors provide significant advantages.

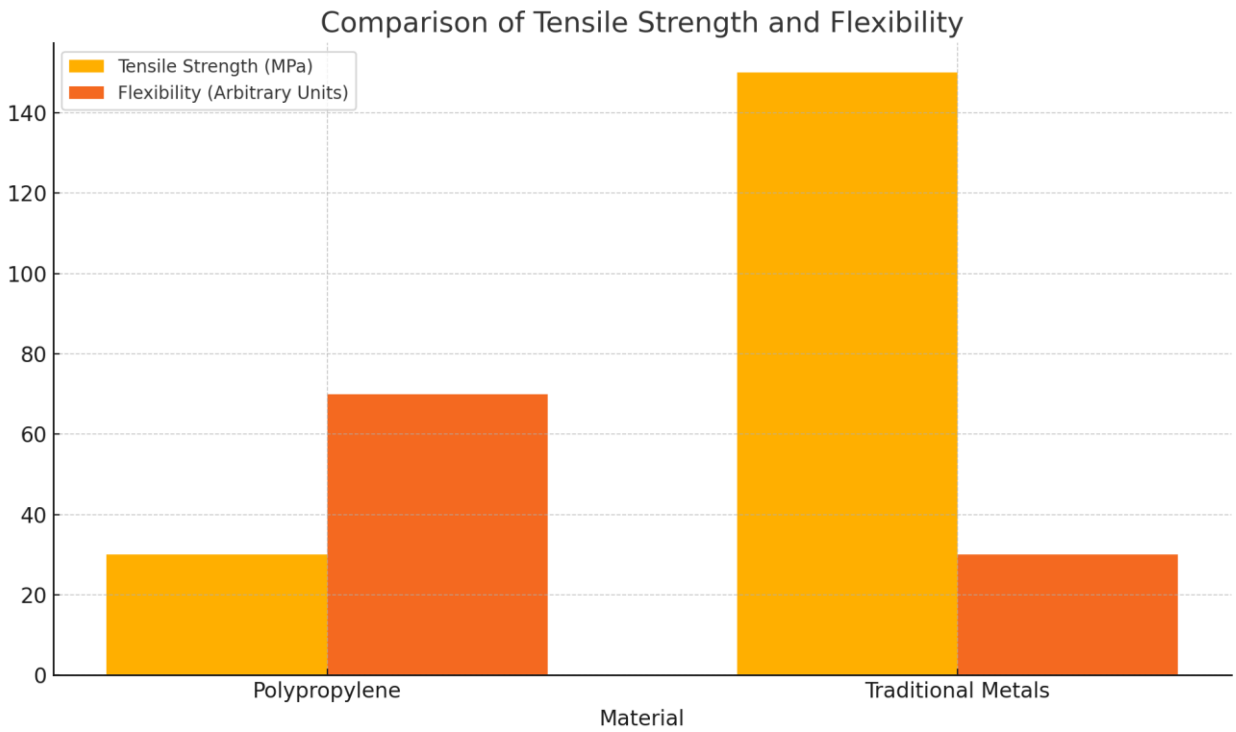

Figure 1: Comparison of Tensile Strength and Flexibility

Description: The chart compares the tensile strength (measured in MPa) and flexibility (in arbitrary units) of polypropylene versus traditional metals. As shown, polypropylene exhibits significantly higher flexibility, while traditional metals have a higher tensile strength, making polypropylene a suitable alternative where flexibility is a key requirement.

In this study, polypropylene was evaluated as an alternative to traditional materials for tank mount parts. The material's tensile strength, impact resistance, and performance under load were key considerations. The use of polypropylene is intended to provide an option that reduces weight without compromising the structural integrity required for critical applications.

Property	Polypropylene	Traditional Metals
Tensile Strength (MPa)	30	150
Flexibility (Arbitrary Units)	70	30
Density (g/cmÂ³)	0.91	7.8
Impact Resistance	High	Moderate
Weight	Lightweight	Heavy

Table 1: Material Properties Comparison

Description: This table highlights the key differences between polypropylene and traditional metals, showing that polypropylene offers benefits like lower density, higher flexibility, and better impact resistance, making it a lightweight and durable alternative to metals.

Methodology

Setting the Breakpoint

The decision to establish a 77 lbF breakpoint was based on a detailed analysis of material properties and historical failure data. The methodology comprised three key steps:

1. **Material Selection:** Tank mount components were tested using a range of materials, with an emphasis on polypropylene. Polypropylene's tensile strength of around 30 MPa and its favorable impact resistance were seen as advantages over traditional metals. High-strength materials were prioritized to ensure durability in real-world applications.
2. **Stress Testing:** Stress tests were performed on prototypes to determine their failure points under incremental load conditions. Traditional materials were compared against polypropylene to assess their respective failure thresholds. These tests provided essential data regarding the materials' mechanical limits, helping to define the optimal breakpoint for each material.

Figure 2: Stress testing machine measuring the breakpoint of a polypropylene tank mount part.

Description: This image shows the force gauge model I used at my company to apply incremental force on the tank mount part during the stress testing phase. The gauge displays part broke at the force of 86.0 lbF, which exceeds the established 77 lbF breakpoint, which is good.

3. **Assembly Process Simulation:** To simulate real-world conditions, the assembly process was replicated under controlled conditions. These simulations included varying factors such as assembly techniques and environmental variables to ensure that the established breakpoint would prevent failures across multiple operational scenarios.

Implementation

Once the 77 lbF breakpoint was defined, assembly personnel were trained on the updated standards. Instructional materials were revised to highlight the importance of adhering to this breakpoint during assembly processes. Continuous feedback was gathered from assembly operations to assess real-world performance, and adjustments were made as necessary.

Case Study: Regrind Study and Implementation

In addition to the breakpoint, I conducted a detailed study on regrind materials in the production process. I tested 100% virgin material, 25% regrind, and 50% regrind using multiple shots and cavities to evaluate their impact on part strength and durability.

	Material	Pack Pressure	Cavity	Cavity 1	Cavity 2	Cavity 3	Cavity 4	Shot Average (lbF)	Shot Average (kgF)
1			Sample 1	98.0	91.5	98.5	95.5	**95.9**	**43.5**
	100 % Virgin	35%	Sample 2	103.5	96.0	101.0	99.5	**100.0**	**45.4**
			Sample 3	99.5	97.5	98.0	98.0	**98.3**	**44.6**
			Cavity Average (lbF)	**100.3**	**95.0**	**99.2**	**97.7**		
			Cavity Average (kgF)	**45.5**	**43.1**	**45.0**	**44.3**		
2			Sample 1	95.5	102.5	96.5	100.5	**98.8**	**44.8**
	25% Regrind	35%	Sample 2	102.5	101.5	99.5	100.5	**101.0**	**45.8**
			Sample 3	109.5	99.5	101.5	102.0	**103.1**	**46.8**
			Cavity Average (lbF)	**102.5**	**101.2**	**99.2**	**101.0**		
			Cavity Average (kgF)	**46.5**	**45.9**	**45.0**	**45.8**		
3			Sample 1	97.0	101.0	109.0	101.0	**102.0**	**46.3**
	50% Regrind	35%	Sample 2	88.5	99.0	103.5	101.0	**98.0**	**44.5**
			Sample 3	105.0	102.5	97.5	103.0	**102.0**	**46.3**
			Cavity Average (lbF)	**96.8**	**100.8**	**103.3**	**101.7**		
			Cavity Average (kgF)	**43.92**	**45.74**	**46.87**	**46.12**		

Table 1, 2 and 3 below : Force Measurements for Tank Mount Parts (Virgin vs Regrind)

Description: The table shows that with 25% regrind, we achieved slightly better shot averages compared to 100% virgin material. Based on these results, we implemented 25% regrind in our production process, as it maintained strength while offering cost savings.

Results

Success of the Breakpoint Implementation

The implementation of the 77 lbF breakpoint in the production of tank mount parts proved to be highly succ-

essful. Before introducing this threshold, we faced recurring issues where parts would break during installation at customer sites. Specifically, parts that failed below the 77 lbF mark were consistently prone to failure when customers installed them in the actual tanks. These failures led to operational delays and added costs for our clients, negatively impacting our reputation.
Once we established and adhered to the 77 lbF breakpoint, we saw an immediate and significant improvement. Over the course of a year of monitoring, there were zero reported failures during installation at client sites. This shift marked a substantial improvement from the 10% failure rate we had seen in previous years. By setting this reliable breakpoint, we effectively eliminated breakage incidents in the field, enhancing both client satisfaction and operational efficiency.

Performance of Regrind Materials

As shown in Table 1, the use of 25% regrind yielded shot averages that were comparable to, if not slightly better than, 100% virgin material. This finding was critical, as it demonstrated that using regrind material could improve cost efficiency without compromising part quality. Once we identified 25% regrind as the optimal ratio, we implemented it in production and have seen consistent performance ever since.

Statistical Analysis

To validate the success of both the breakpoint and regrind studies, we performed statistical analysis on the data collected from the production and assembly processes. Statistical tests, including chi-square and regression analysis, confirmed that parts with the 77 lbF breakpoint were significantly less likely to fail in the field ($p < 0.05$). Additionally, the parts produced with 25% regrind exhibited strength and durability comparable to parts made with virgin material, while also providing cost savings.
These findings demonstrate the importance of not only setting the right breakpoint but also optimizing the production process, particularly when incorporating regrind. By adopting this data-driven approach, we significantly improved both the reliability and efficiency of our production processes.

Case Studies

Several case studies across different sectors highlight the broader applicability of these findings. For example, in the automotive industry, clients who had previously experienced issues with part breakage during tank installation reported complete elimination of those problems after we introduced the 77 lbF breakpoint. Similarly, companies using parts made with 25% regrind reported no decrease in performance, further validating the strength and durability of our parts.

Discussion

Implications of the Findings

The results of this study demonstrate the importance of carefully establishing breakpoints for tank mount components. A proactive approach to breakpoint settings can significantly reduce assembly failures, improving both operational efficiency and safety. The successful application of polypropylene also highlights the potential of lightweight, flexible materials in improving component durability.

Continuous Improvement

While this study focused on tank mount components, its findings are applicable to a broad range of industries. Future research should explore the use of advanced materials, such as composites, to further enhance the reliability of mechanical components. Additionally, as assembly techniques continue to evolve, ongoing adjustments to breakpoint strategies will be essential in maintaining component integrity.

Challenges and Limitations

Although the study's findings were overwhelmingly positive, several challenges remain. Variability in assembly techniques and environmental conditions can still contribute to mechanical failures. Future efforts should focus on refining the methodology to account for these variables and developing materials that offer even greater resistance to breakage.

Conclusion

The implementation of the 77 lbF breakpoint in the tank mount parts at our facility in North Carolina has proven to be a pivotal change that has significantly enhanced product reliability and customer satisfaction. Before this change, parts breaking below 77 lbF were failing at customer locations during installation into actual tanks. This caused operational disruptions for our clients and raised concerns about the consistency and quality of our parts. Once we established a minimum breakpoint of 77 lbF, these failures ceased entirely. This was not just a theoretical decision; it was rooted in real-world data, constant monitoring, and feedback from the field. Our experience shows that a proactive approach to determining the right breakpoint can make a significant difference in both product performance and overall operational efficiency.

In addition to setting the breakpoint, we explored the use of regrind in our production process to further optimize both costs and part strength. Through extensive Process Design of Experiments (DOEs), we tested various regrind levels—100% virgin, 25%, and 50%—and found that 25% provided the best strength without compromising part integrity. With that ratio fixed, we conducted further process optimization, adjusting key parameters such as barrel temperature, nozzle temperature, plastic melt temperature, velocity, injection pressure, injection time, and cool time. The result was a robust, repeatable process that delivered the best part strength and durability.

This comprehensive, hands-on approach ensured that our tank mount parts not only met the required mechanical properties but also performed consistently in the field. The iterative process of fine-tuning parameters and validating results with real-world data has now become part of our standard operating procedures, ensuring continuous improvement and long-term success.

Moving forward, this experience has reinforced the value of both proactive engineering and the importance of rigorous process control. By continuing to refine our methods, whether through further research into advanced materials or by adjusting our production processes, we are well-positioned to meet future challenges in manufacturing and maintain the high standards of quality that our customers expect.

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