Best Practices for Reducing Busbar Weight While Maintaining Ampacity and Performance

Reducing the weight of busbars while maintaining ampacity (the ability to carry current) can be challenging, especially for applications where weight is a critical factor, such as aerospace, automotive, etc.

Some of the key considerations for reducing busbar weight include

- **Material Selection:** Choose high-conductivity materials like aluminum or copper alloys that offer the required ampacity but are lighter than traditional materials.
- **Optimized Cross-Sectional Design:** Use a busbar design that optimizes the cross-sectional area. This can involve optimizing the height to width (d/w) ratio and/or using hollow or composite structures that maintain strength and conductivity while reducing weight.
- **Advanced Manufacturing Techniques:** Employ advanced manufacturing methods to create optimized busbar geometries that reduce material use while maintaining strength and conductivity.
- **Integrated Cooling Systems:** Incorporate cooling channels or systems into the busbars to improve heat dissipation, allowing for smaller cross-sections and reduced weight without overheating.
- **Strategic Layout and Segmentation:** Optimize the layout of busbars and segment them where possible to reduce overall weight while maintaining efficiency.

By addressing these key issues, it's possible to achieve lighter busbars without compromising their ability to carry the required electrical currents. The following sections focus primarily on materials choice, cross-sectional design and advanced manufacturing techniques.

Materials - Copper vs. Aluminum

Choosing between copper and aluminum for busbars involves considering several trade-offs based on the application requirements:

- **Weight:** Aluminum is lighter than copper for the same volume, making it advantageous in applications where weight is a concern, such as aerospace or automotive industries.
- **Conductivity:** Copper has higher electrical conductivity than aluminum. This means copper busbars can carry the same current with smaller cross-sectional areas compared to aluminum, reducing overall weight and size for a given current capacity. Click here for details on copper vs aluminum ampacity.
- **Cost:** Aluminum is generally less expensive than copper per unit weight. This cost advantage can be significant in large-scale applications where extensive lengths of busbars are required.
- **Corrosion Resistance:** Copper is more resistant to corrosion compared to aluminum in most environments. This makes copper more suitable for outdoor or corrosive environments unless aluminum is properly protected with coatings.
- **Mechanical Properties:** Copper is softer and more ductile than aluminum, which affects ease of machining, bending, and handling during installation. Aluminum requires more careful handling to avoid damage.

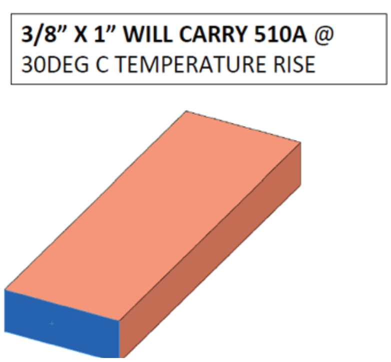
Aluminum busbars are often used as electrical conductors in power distribution systems, where heat can easily be dissipated. Because of the low value of the metal, it can be the best economic option for these applications. Aluminum conducts at a lower level than copper. To compensate for heat dissipation, we often recommend creating a larger surface area to improve heat exchange for more efficient thermal dissipation.

Optimizing Busbar Cross-Section Design Attributes (d/w ratio)

The d/w ratio (height to width ratio) is a critical factor in busbar design that influences several aspects of its performance:

- **Electrical Performance:** The d/w ratio affects the electrical resistance of the busbar. A lower d/w ratio generally reduces resistance because it provides a more direct path for current flow, minimizing the skin effect (where current tends to flow near the surface of the conductor).
- **Mechanical Strength:** The d/w ratio also influences the mechanical strength of the busbar. A higher d/w ratio typically provides greater mechanical stability and rigidity, which can be important in applications where mechanical stress or vibration is a concern.
- **Heat Dissipation:** For busbars carrying high currents, heat dissipation is crucial. The d/w ratio impacts the surface area-to-volume ratio, which affects how efficiently heat can be dissipated from the busbar. Lower d/w ratios generally provide better heat dissipation.
- **Manufacturing Considerations:** The d/w ratio can influence manufacturing costs and feasibility. Extremely low d/w ratios might require specialized manufacturing techniques, while very high ratios could lead to material wastage or difficulty in achieving uniform current distribution.

Current carrying is essentially a trade off between temperature rise and conductor cross sectional area. The current can also be affected by the shape of the conductor. Larger surface area will dissipate heat more quickly, carrying more current with the same temperature rise.



Reducing weight in busbar design often involves optimizing the d/w ratio to balance these factors based on the specific requirements of the application, including electrical current capacity, mechanical stress, heat dissipation needs, and manufacturing constraints.

Tests show that for practical purposes, copper bus bar sizes can be converted to aluminum sizes for equal temperature rise by either of the following two methods:

- Increase the width of the aluminum bar 27 percent. Example: To achieve the same temperature rise, a 5” x 1/4” aluminum bar is equivalent to a 4” x 1/4” copper bar.
- Increase the thickness of the aluminum bar about 50 percent. Example: To achieve the same temperature rise, a 4” x 3/8” aluminum bar is equivalent to a 4” x 1/4” copper bar.

Increasing the cross-sectional area by increasing the width not only reduces the resistance heating but also substantially increases the area available for heat dissipation.

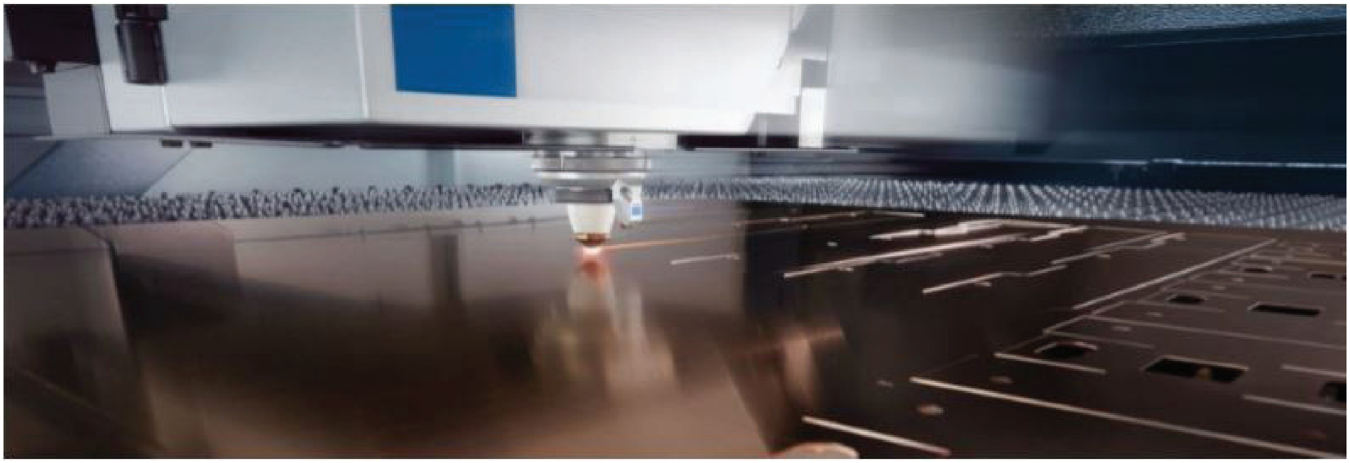
Advanced Manufacturing Techniques

Your choice of a busbar vendor should not limit your design or manufacturing options but rather should offer the widest range of choices to meet your specific application requirements.

As one of the largest electrical components manufacturers in North America, Storm Power Components sources more than seven million pounds of copper and aluminum every year. This advanced sourcing approach mitigates inventory overhead from production costs, while providing optimal flexibility for assessing and testing different material approaches. We also have in-house plating and powder coating capabilities that enable protection of chosen materials from various environmental factors.

Storm Power's fabrication techniques include:

- Forming & Bending - Conventional, offset, & side
- Stamping - Coil line process & in-house die fabrication
- Cold Cutting & Shearing - High and low volume sawing/shear
- Machine Punching - CNC, automated, & single stroke turret
- Precision CNC Machining - Turning & milling with multi-axis
- Precision Machining - Turning & milling with Swiss-style screw
- Press/Fused Welding and Brazing
- CNC Water Jet
- Fiber Laser

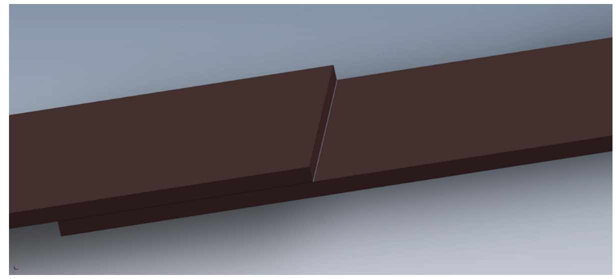


Storm Power has one of the largest cutting beds in manufacturing today. Our custom built bed can handle parts up to 20 feet in overall length. Couple that with 6,000 watts of cutting power, our laser is a one-of-a-kind.

Storm Power also leads the industry in advanced design and production of laminated busbars, which can be of benefit for optimizing weight vs performance in a number of ways. By combining the busbar and all associated cabling, components etc. into a single pre-assembled compact structure, laminated busbar designs can help minimize size and weight while reducing overall heat dissipation. Storm holds the distinction of fabricating the largest laminated busbars in the world, as well as some of the most complex and compact designs.

Strategic Layout and Segmentation

Another key factor for reducing busbar weight and optimizing performance involves an overall strategic approach to the busbar layout, including potential segmentation of the design into multiple smaller busbars that are then joined together.



Taking a holistic approach to busbar design, from ideation through prototyping to full production, is a key factor for optimizing weight along with all the other performance specifications and application-specific requirements.

This includes strategies such as incorporating components, connectors, fasteners, etc. in a manner that takes into account overall weight of the final end application, rather than just the busbar itself.

Summary

In summary, it is always a good practice to treat busbar design as a holistic endeavor that starts with understanding the goals, specs, and operational parameters for the target system and the end application.

Therefore, reducing weight needs to always take into consideration the overall weight budget for the system, along with maintaining required ampacity, managing heat dissipation issues, environmental considerations, life-cycle projections, and of course total costs of ownership.

At Storm Power Components, our engineering teams have decades of experience with designing complex busbars that have proven reliable in the most demanding of deployments. This is because we always start with the end goal of the system in mind and then bring our knowledge, experience, and creativity together in a holistic manner to achieve those goals, including when it comes to selecting and implementing the best methods and practices for reducing weight and optimizing performance for any application.