

Chainmail Armor: Form and Function

Chainmail is a form of flexible armor made up of thousands of interlocking metal rings. It is most commonly associated with Medieval times and knights in shining armor, but chainmail was used by many cultures around the world. In more recent times you may have seen it at a local Renaissance festival or reenactment. Although chainmail may appear simple at a glance, there are a number of complex concepts interacting to produce a protective garment. These concepts can be broken down into the actual design of the chainmail and how it functions to protect the wearer.

>The Design of Chainmail:

A garment of chainmail involves a number of different factors including the size and diameter of the rings, the type of weave used, and the orientation of the weave relative to the wearer.

Rings:

At its heart chainmail is nothing more than thousands of interlocking rings carefully interlaced in a repeating pattern. One of the most crucial decisions in making a piece of chainmail is what size rings will be used. This decision will also be contingent on what diameter of wire is used to make the rings and their material.

An example of this consideration is you may not want to use titanium to make small diameter rings because it is difficult to bend and have it hold its shape. In an application with small rings you may want to use aluminum or mild steel wire which bends easier.

Figure 1 shows some examples of rings used to make chainmail. The internal diameter varies for the three larger rings from 0.25” to 0.50”. The small wire ring has an internal diameter of 0.125”.



Figure 1: Rings

Weave:

The weave of chainmail dictates a lot about how the garment will wear and its comfort to the user. Using a very tight weave may provide great protection, but it can severely limit flexibility, very often significantly in one direction.

Thus a balance between the size of the rings and the weave chosen must be found. Figure 2a and 2b outline this flexibility issue. In Figure 2a we can see that this piece of chainmail can easily be folded over parallel with the rows of rings, but in Figure 2b the piece of chainmail locks up when bent along the rows of rings.



Figure 2a



Figure 2b

The most common weave is a 4-in-1, or 4-to-1 weave. This simply means that every ring, with the exception of those at seams and edges, has four other rings linked to it (Figure 3). In some cases a 6-to-1 pattern may be used, which simply means that every ring has six others linked to it (Figure 4). The 4-to-1 weave was the most common in western Medieval styles, and could be found in some eastern chainmail armor.



Figure 3: 4-to-1 weave



Figure 4: 6-to-1 weave

Japan also developed its own patterns of chainmail (Figure 5). Their application for chainmail was more to fill in the gaps between rigid plates than to make entire garments. Their weaves were also characteristic in that the rings formed two planes perpendicular to one another, with one of those planes parallel to the wearer. This is illustrated in Figure 6. The plane parallel to the wearer is marked with a red line, while the plane perpendicular to the wearer is marked with a yellow line.



Figure 5: Japanese style weave

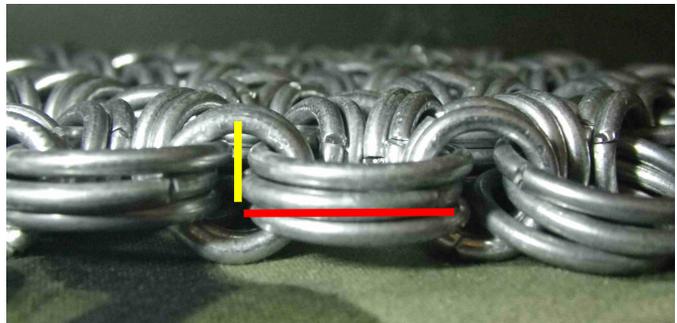


Figure 6: Japanese chainmail plane orientations

Western style chainmail also possess two planes of rings that are approximately perpendicular to one another, but that are at an angle to the wearer. In Figure 7 the planes of the chainmail are labeled in blue, while the plane of the wearer is labeled in green.

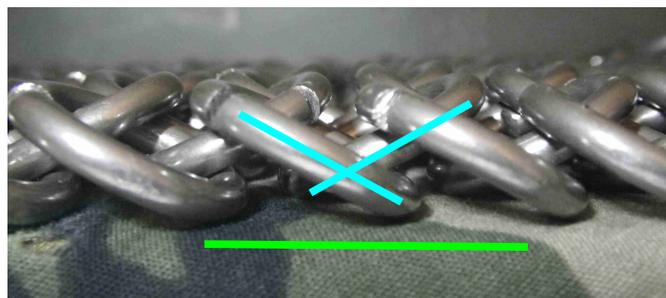


Figure 7: Western chainmail plane orientations

Orientation:

An important consideration for the garment is how a weave is oriented. This can affect how well chainmail can protect the wearer. In the case of 4-to-1, there are two orientations. In one orientation the rings pull against one another and the weave is stretched to its maximum. This inhibits flexibility and protection (Figure 8).

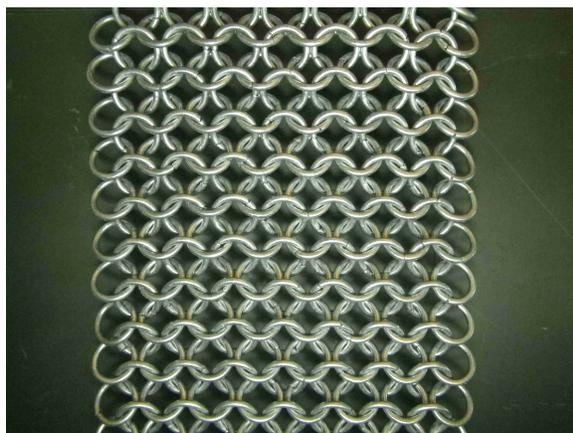


Figure 8: 4-to-1 hanging

If the weave is rotated 90 degrees, the rings hang from one another and are aligned in a more linear fashion. This allows for greater flexibility and better protection (Figure 9).

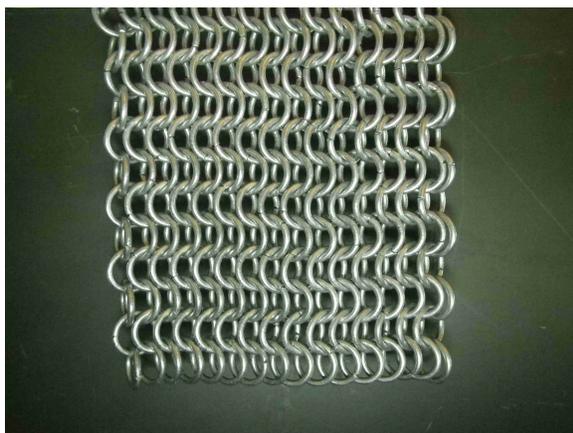


Figure 9: 4-to-1 hanging, rotated 90°

The orientation must constantly be considered and can change throughout the garment. This is usually the case with the arms of a shirt. Compensating for this may necessitate the use of a seam to join differently oriented pieces of chainmail. Figure 10 shows a seam between two pieces of chainmail that are 90 degrees to one another.



Figure 10: Seam joining

>How Chainmail Protects (or Doesn't):

Chainmail is designed to address certain threats, but like any armor system it has its strengths and weaknesses. It is designed to protect against certain threats, but is susceptible to others.

Protection:

Chainmail was primarily designed to protect against slashing threats from a sword or knife. It works by providing a strong, flexible front to meet the sharp edge of a blade. It helps to spread out the force of the blade's edge and prevent it from cutting into the wearer. We can see an exaggerated illustration in Figure 11 of this concept. The edge of the wooden sword has a given thickness which can transfer force from a hit (left side), but when chainmail is introduced the effective width is increased (right side). This spreads the force over a larger area.



Figure 11: Chainmail providing protection

Chainmail can also provide some protection from blunt force by a similar mechanism. The chainmail helps to absorb and distribute the force of a hit over a larger area. This helps to reduce injury, but does not eliminate the potential of becoming injured.

Weaknesses:

Although chainmail can do well at protecting against slashing, it has other weaknesses which have been exploited throughout history. First and foremost, chainmail does not stand up well to impacts from very pointy objects, like tips of swords. This places an extreme amount of force on very few rings making failure of the armor likely. As with today, armor piercing ammunition existed in the past in the form of the bodkin. This is essentially an arrow that has a very long, thin point. This allows it to fit between the links of chainmail and injure the wearer. Chainmail in general does not do very well against arrows since it is very easy for them to overload individual rings, or fit between them.

Similarly to arrows, bullets are also effective against chainmail. The high velocity and small diameter of the projectile can easily penetrate chainmail. The quick force on the rings may also cause them to fracture into pieces creating shrapnel that can further injure the wearer.

Figure 12 shows how a narrow diameter pointed implement can penetrate a tight weave of 0.375", 6-in-1 chainmail made with 14 gauge steel wire. It is important to note that the penetrator did not damage the chainmail, but merely slid between the links.



Figure 12: penetration of chainmail

>Conclusion:

Hopefully this document has provided some background into not only the complexity of chainmail, but the complexity of armor as a whole. It's more than just stopping a sword, it is design and engineering working together to protect. The many different aspects of chainmail – ring choice, pattern, and orientation – all work together to bridge form and function.