Kompozit Malzemeler

Polimer Matrisli Kompozitler

Polimer Matrisli Kompozitlerin Üretimi

PMK parçalar çeşitli yöntemlerle üretilebilmektedir. Üretilecek parçanın kalitesine, istenilen özelliklere, miktarına ve maliyetine göre uygun yöntem seçilebilir.

Sıklıkla kullanılan açık kalıplama yöntemleri:

- Elle yatırma (kontakt kalıplama) yöntemi
- Püskürtme yöntemi
- Torba (otoklav) ile kalıplama yöntemi
- Elyaf sarma yöntemi

Kapalı kalıplama yöntemleri:

- Reçine transfer kalıplama (RTM) yöntemi
- Profil çekme (pultruzyon) yöntemi
- Ektrüzyonla kalıplama yöntemi
- Hazır kalıplama yöntemleri – Bulk kalıplama (BMC), levha kalıplama (SMC)
- Enjeksiyonla kalıplama yöntemi
- Savurma kalıplama yöntem

Reçine Transfer Kalıplama (RTM) Yöntemi

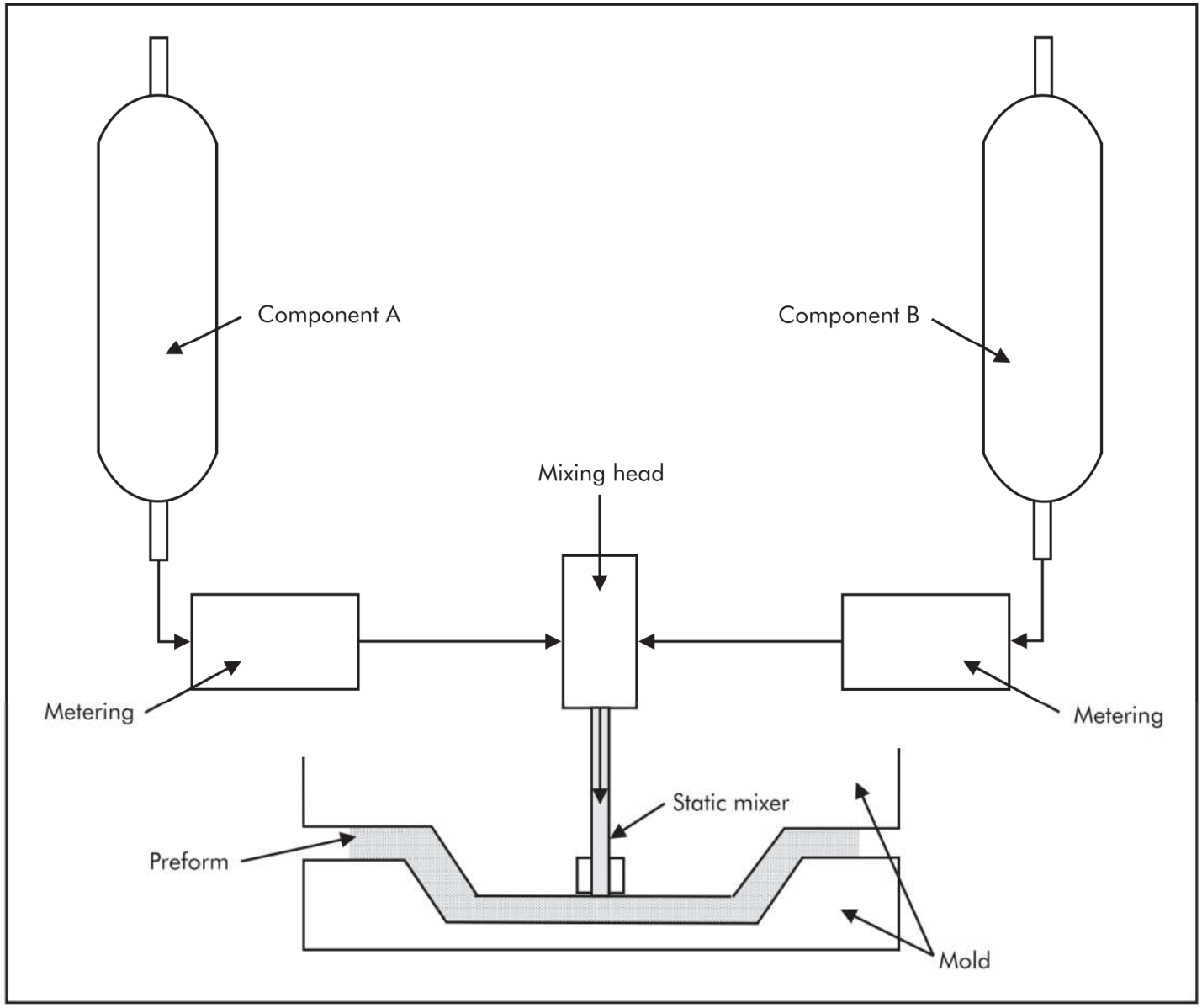


Figure 16-1. Basic resin infusion process.

Reçine Transfer Kalıplama (RTM) Yöntemi

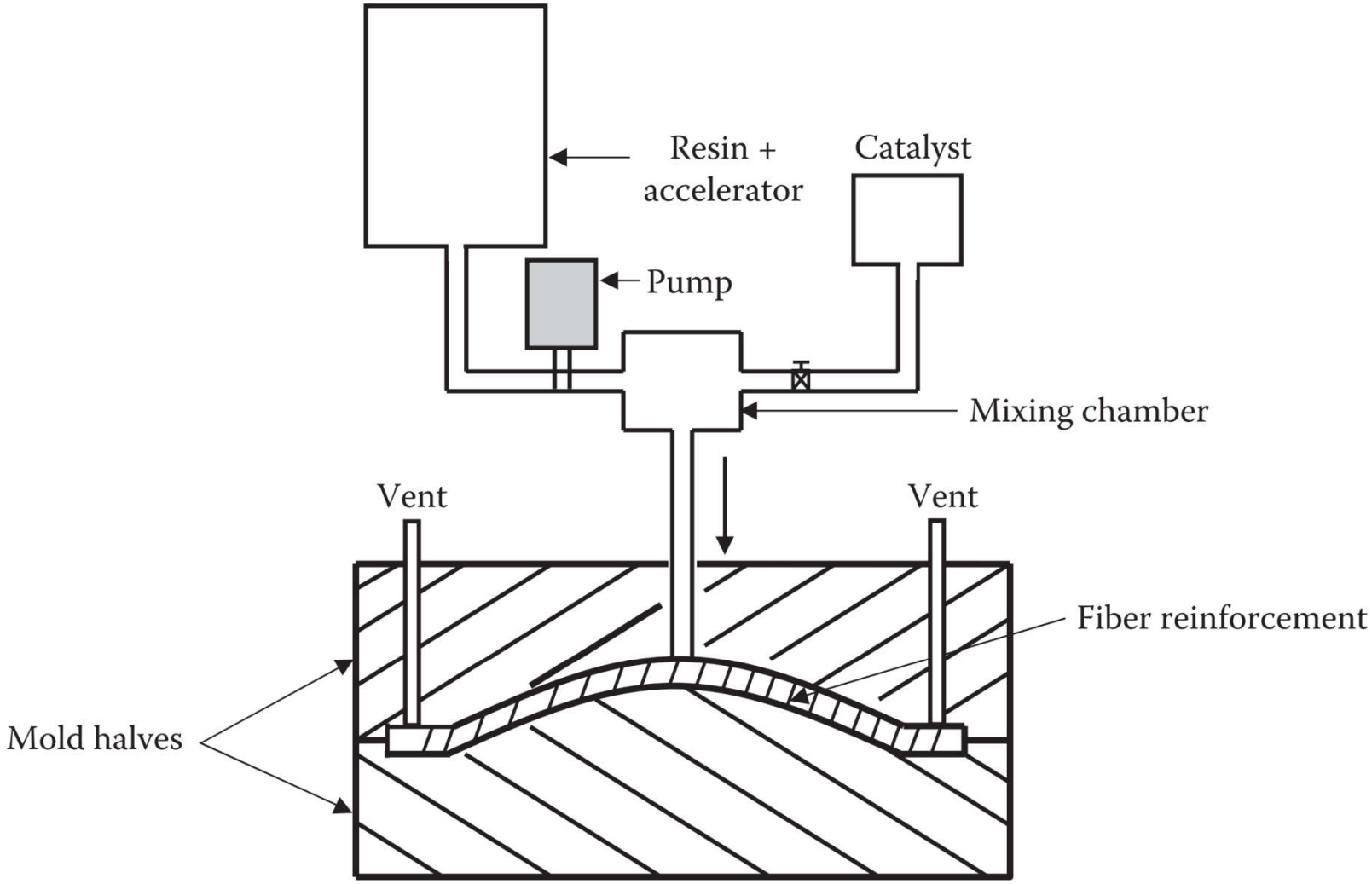


FIGURE 4.4
Schematic of RTM (catalyst injection system).

Reçine Transfer Kalıplama (RTM) Yöntemi

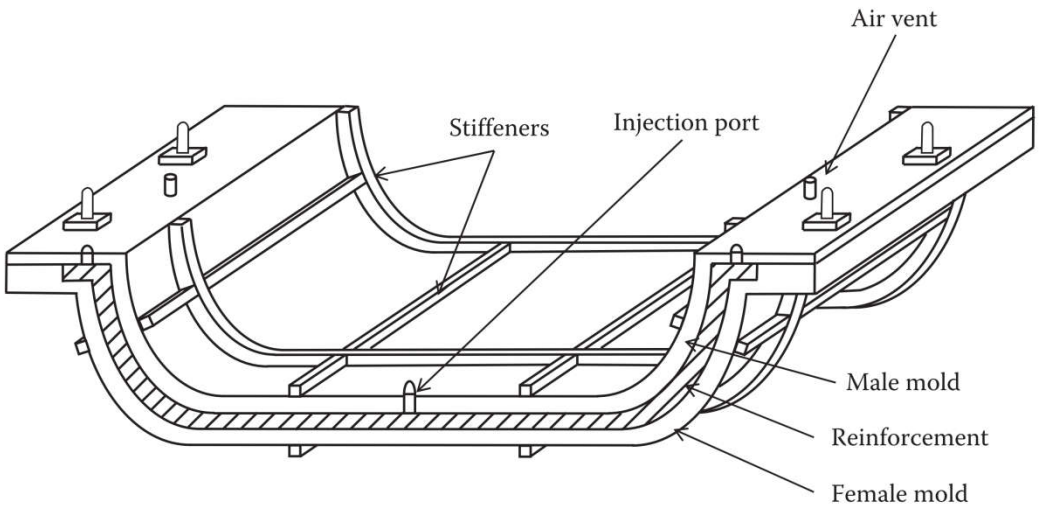


FIGURE 4.5
Schematic of a section of RTM mold with stiffeners.

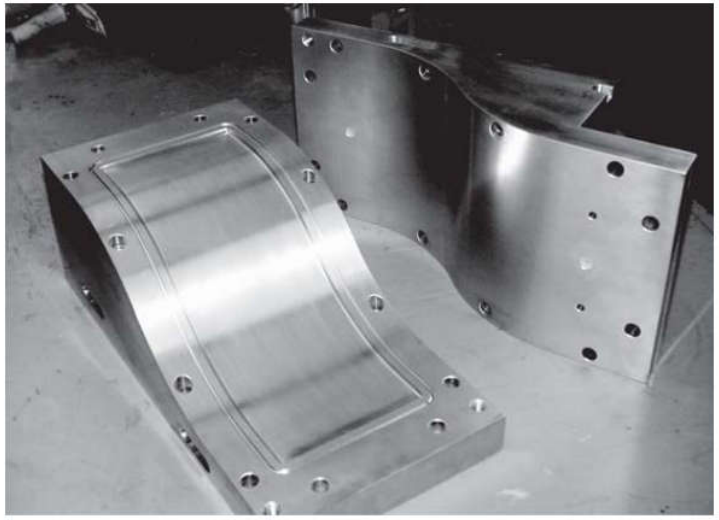
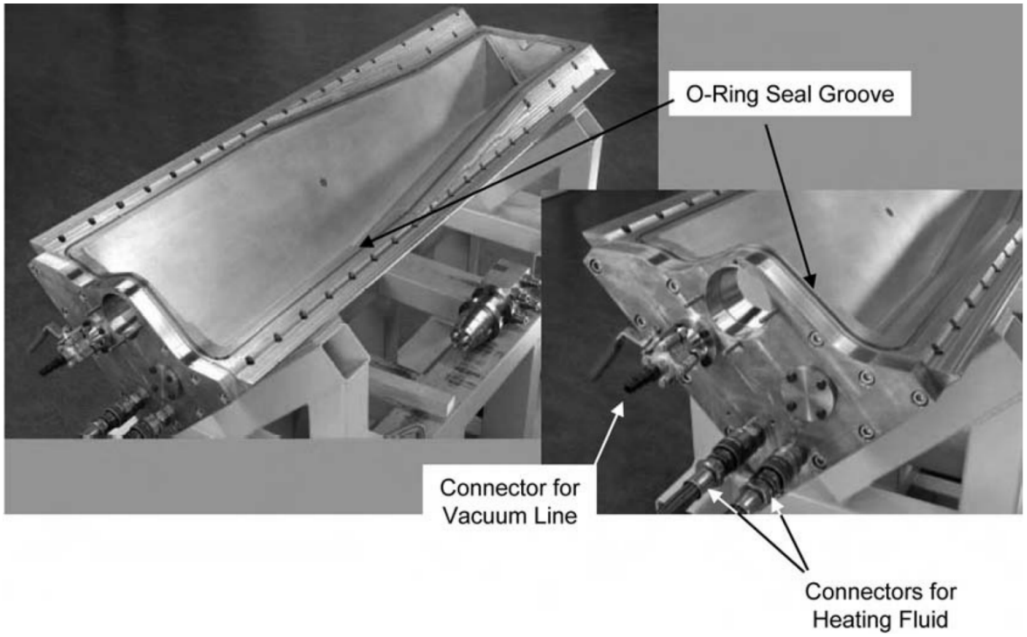
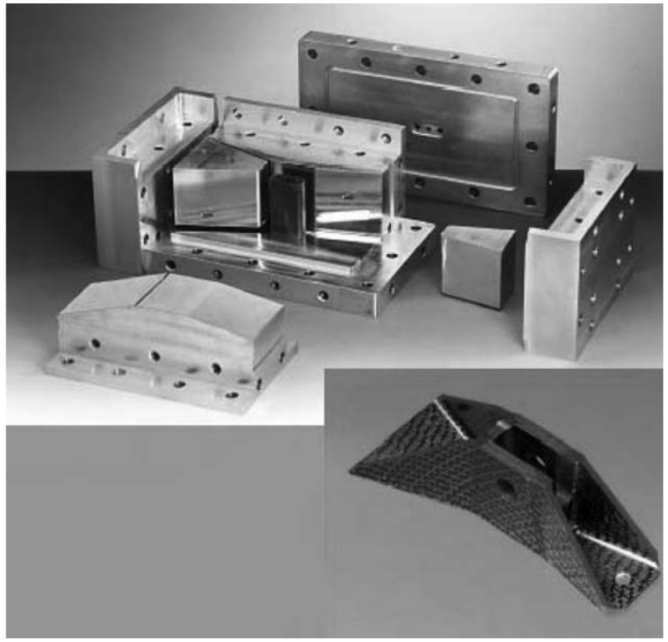


FIGURE 7.4 An RTM mold for a curved piece.





Reçine Transfer Kalıplama (RTM) Yöntemi

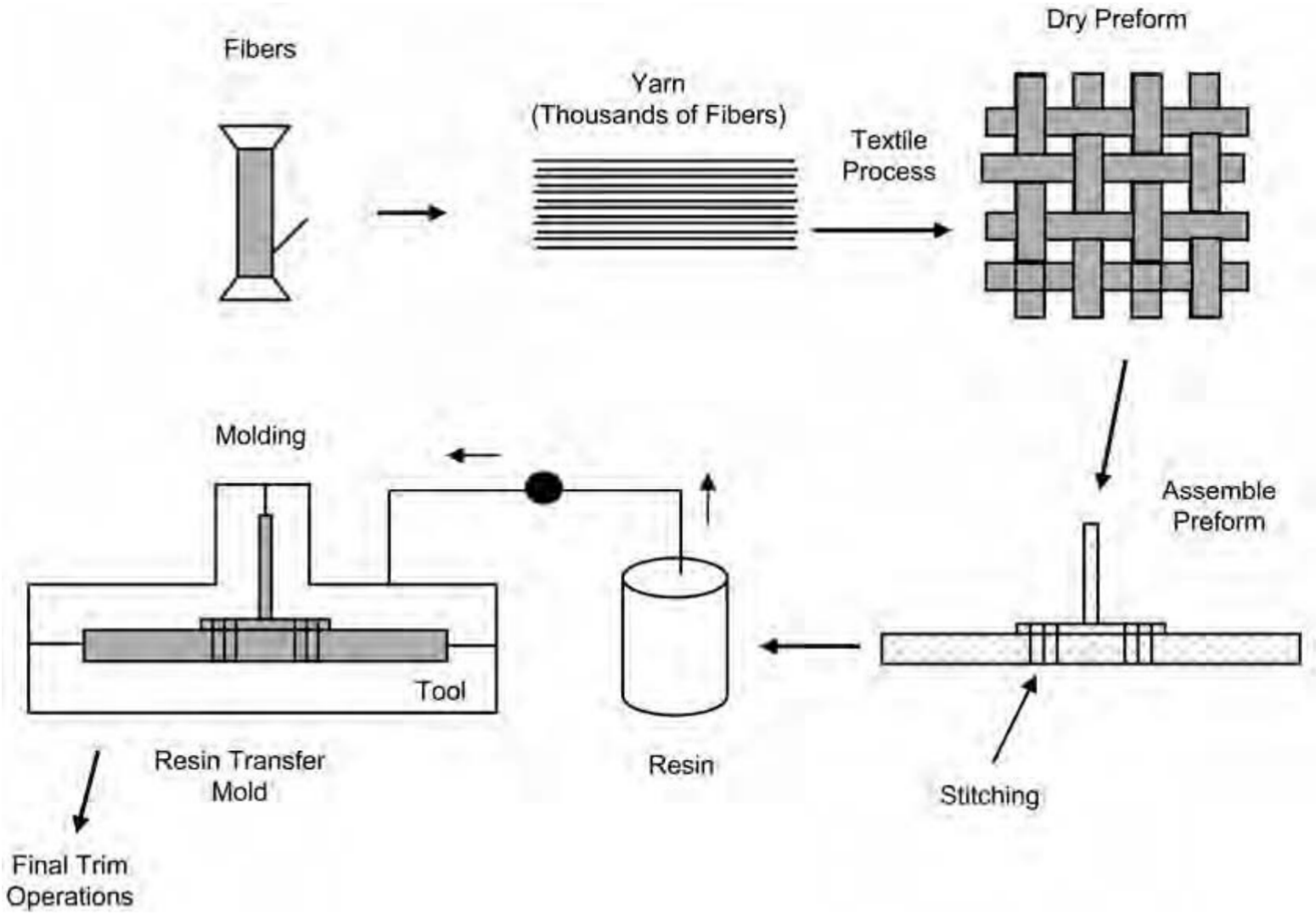
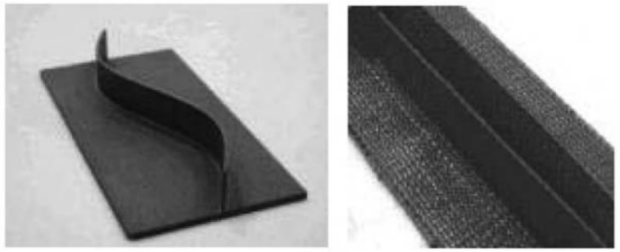
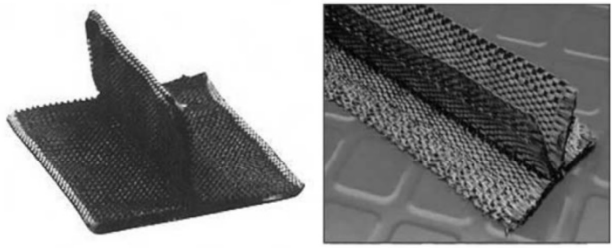


Fig. 5.25 Conceptual process flow for resin transfer molding (RTM). Source: Ref 9

Reçine Transfer Kalıplama (RTM) Yöntemi



T-Stiffened and Pi-Stiffened Panels



3D Woven T-and Pi-Stiffened Preforms

Thick Multiaxial Structures

Fig. 5.29 Three-dimensional (3D) woven preforms

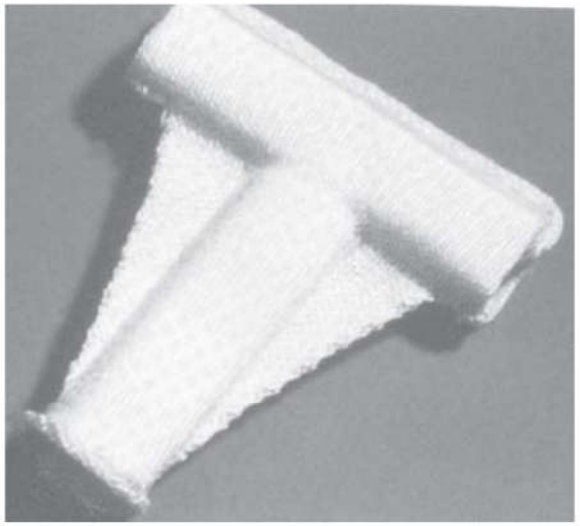
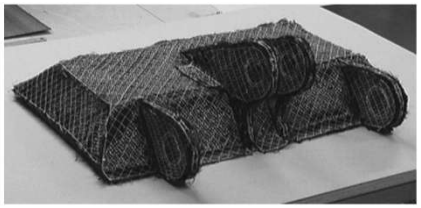
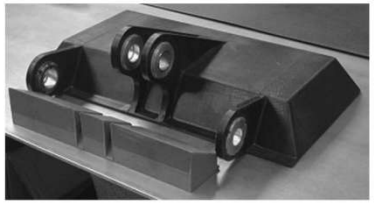


FIGURE 7.8 Knitted glass fiber preform for a stiffened T joint (courtesy of Preform Technologies Ltd.).

Fig. 5.26 Advanced textile material forms. 2-D, two-dimensional; 3-D, three-dimensional. Source: Ref 10



a. Complex aircraft hinge—preform uses stitching technology with textile materials



b. Completed RTM aircraft hinge structure after resin infusion and cure (note metal inserts)

Figure 16-4. RTM aircraft hinge. (Courtesy Scott Beckwith)

Reçine Transfer Kalıplama (RTM) Yöntemi

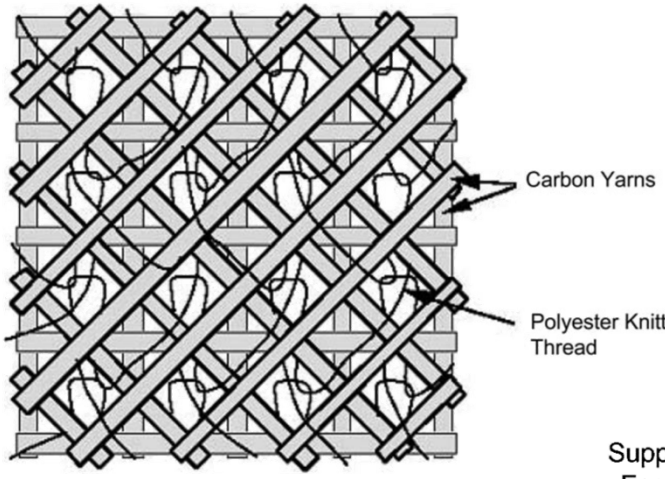
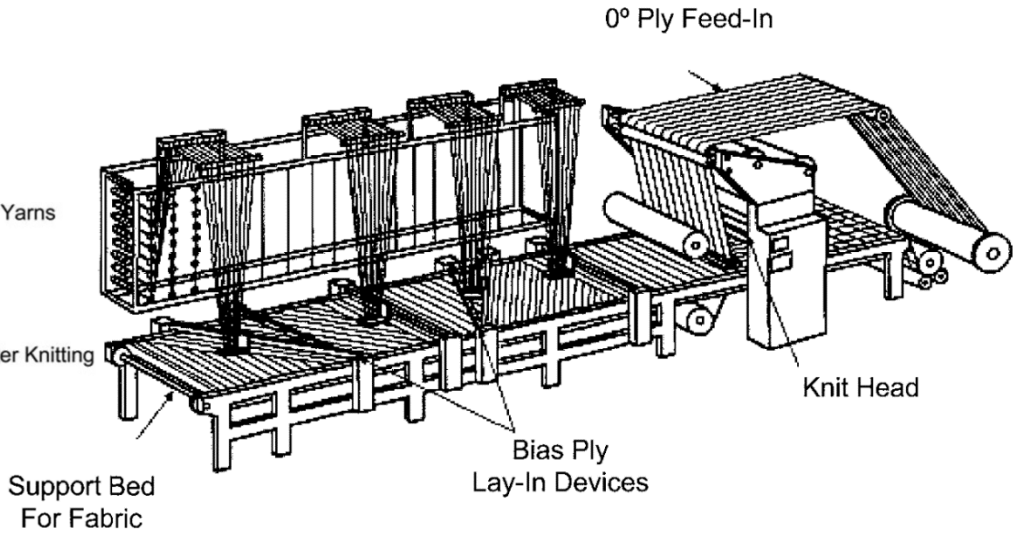


Fig. 5.30 Multiaxial warp knit architecture. Source: Ref 9



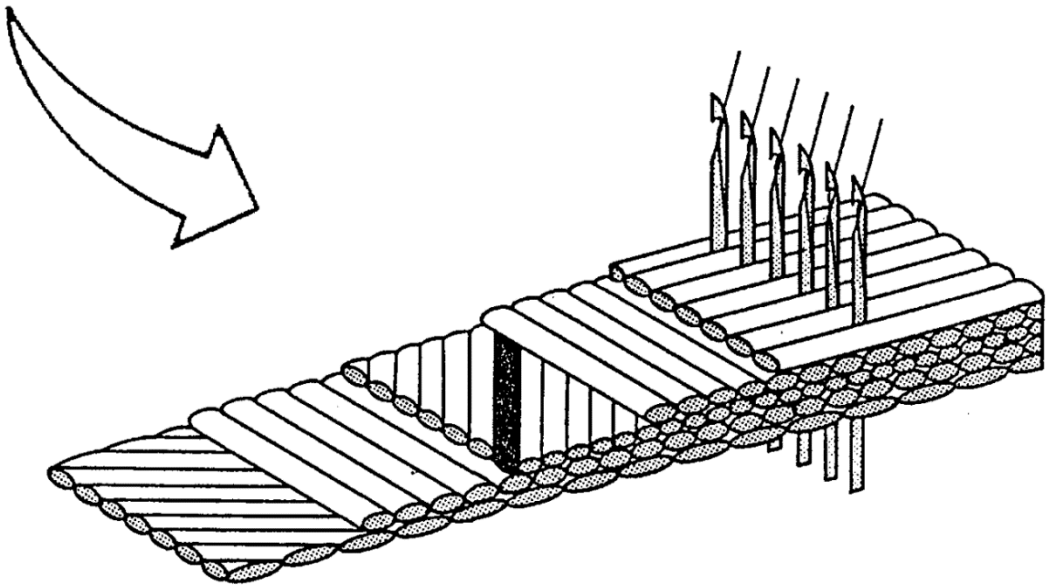


Fig. 5.31 Libra™ warp knitting machine and typical product form produced. Source: Ref 11

Reçine Transfer Kalıplama (RTM) Yöntemi

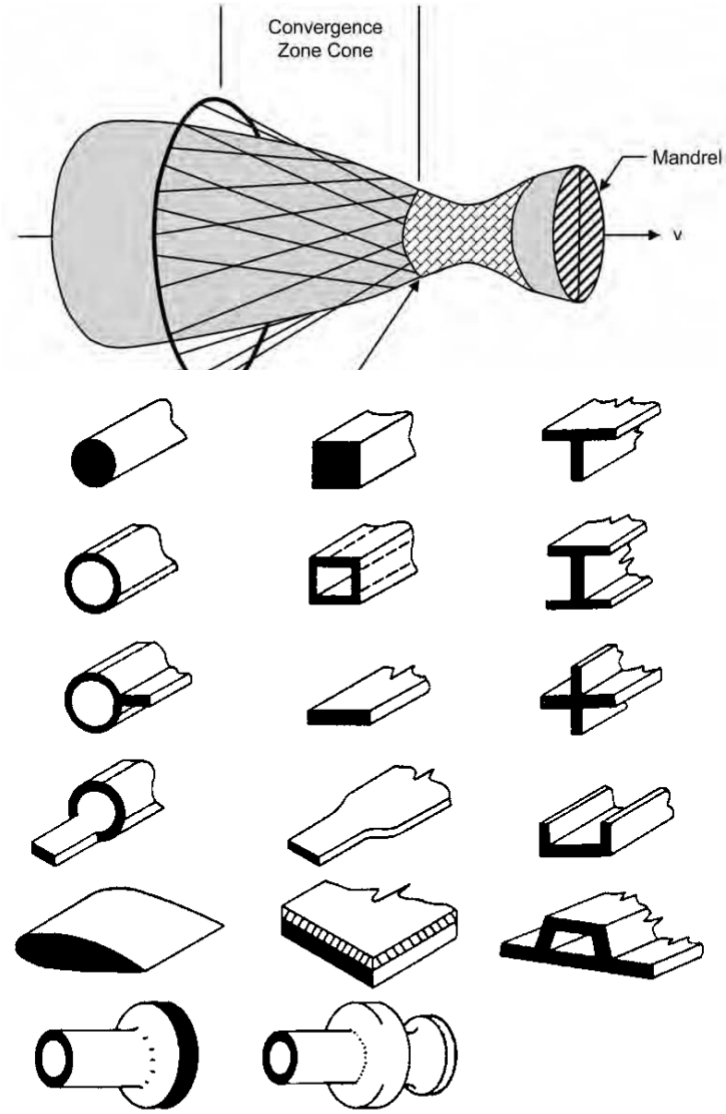


Fig. 5.37 Examples of net shaped three-dimensional braided structures. Source: Ref 13

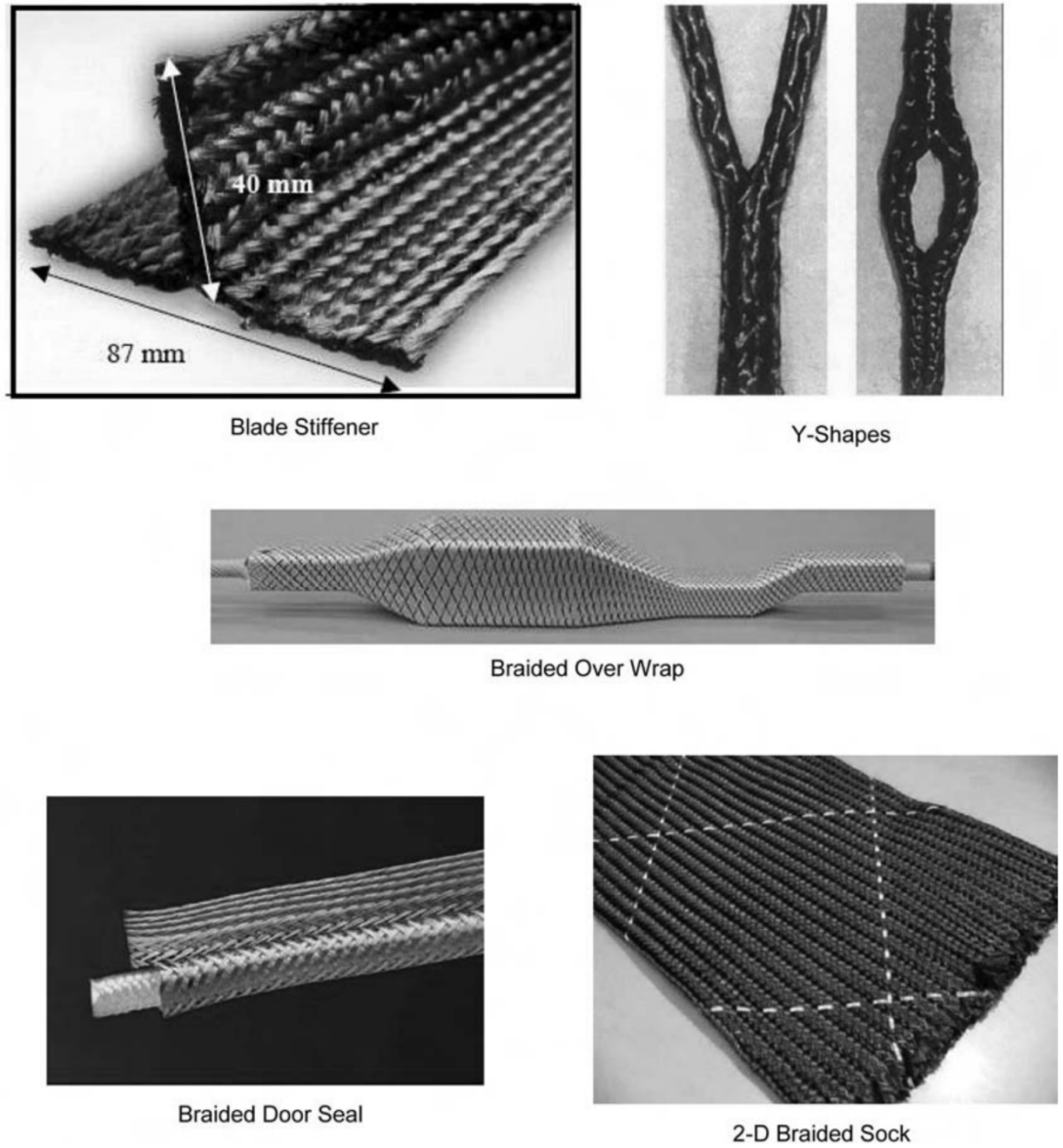


Fig. 5.36 Braided preform examples. 2-D, two-dimensional

Reçine Transfer Kalıplama (RTM) Yöntemi

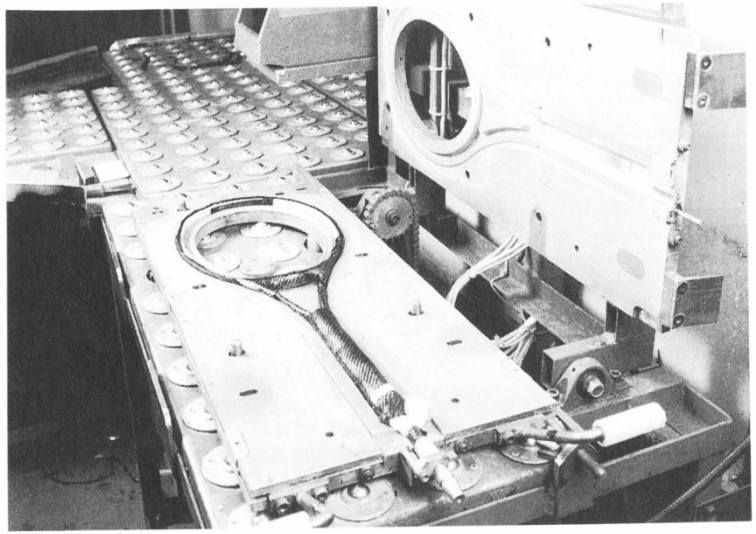


Fig. 11.3 Photograph of equipment for resin transfer moulding production of a carbon fibre reinforced tennis racquet (Blake 1989).

Darcy Kanunu

$$J = -\frac{k}{\eta}\nabla P,$$

J: Hacim akış yoğunluğu (hacim/(alanxzaman))
k: Poroz ortamın (preform) geçirgenliği
η: Reçinenin vizkozitesi

Reçine Transfer Kalıplama (RTM) Yöntemi

Avantajları	Dezavantajları
En iyi boyut kontrolü ve yüksek tekrarlanabilirlik	Kalıp ve parça tasarımı üretilen ürünün özelliklerini belirler
Ek işlem yapmadan her iki yüzeyde de A sınıfı yüzey özellikleri	
Jel kaplama uygulayarak yüzey özelliklerinin geliştirilme olanağı	Geniş ürün gamı için parça maliyeti yüksek olabilir
Hızlı üretim	
Bütün ek parçaların tek bir seferde kalıplanabilmesi	Kalıp doldurma geçirgenliği hakkında çok kısıtlı bir veritabanı var
Düşük emdirme basınçları	
Prototip üretim maliyetleri görece ucuz	Kalıp doldurma yazılımları kısıtlı ya da hala (1999 yılı için) geliştirme aşamasında
Zehirli gaz çıkışı kontrol edilebilir (Kapalı bir sistem)	
Tasarım esnekliği: Takviye elemanları, dizilimleri, iç malzemeler, eklentiler ve karışık malzemeler yerinde kürlenir	Preform ve takviye elemanının kalıp içerisindeki dizilimi kritik öneme sahip
Otoklavla üretimle kıyaslanabilir mekanik özellikler (V_f=0.65)	100-5000 parça arasında üretime uygun
Karmaşık ve geniş parçaların üretim sonrası kesme işlemine gerek kalmadan üretilebilmesi	Vizkozite nedeniyle kısıtlı reçine seçimi
Kürleme için gerekli ısıtma işleminin kalıba entegre edilebilmesi	Hava sıkışması
Soğutma, torbalama gerektirmemesi	
Otomatikleştirilebilmesi	

Reçine Transfer Kalıplama (RTM) Yöntemi

En iyi b	ürünün
Ek işlem	
Jel kapla	liyeti
Hızlı ür	
Bütün el	kkında
Düşük e	ır
Prototip	lı ya da
Zehirli g	me
Tasarım eklentile	n kalıp e sahip
Otoklav	uygun
Karmaş gerek ka	reçine
Kürleme	
Soğutma	
Otomati	

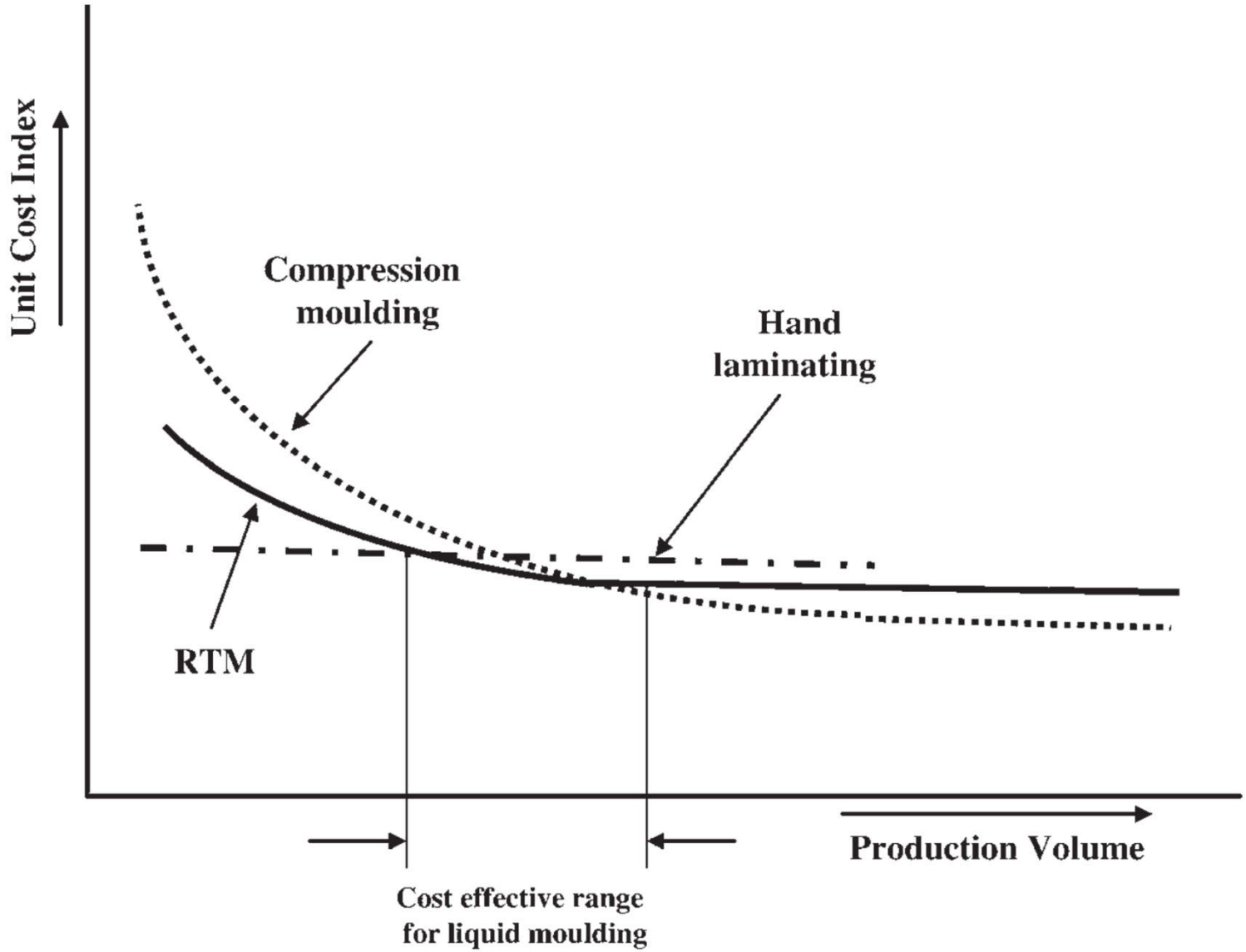


FIGURE 7.2 Cost versus production volume of different manufacturing processes.

Vakum Destekli RTM

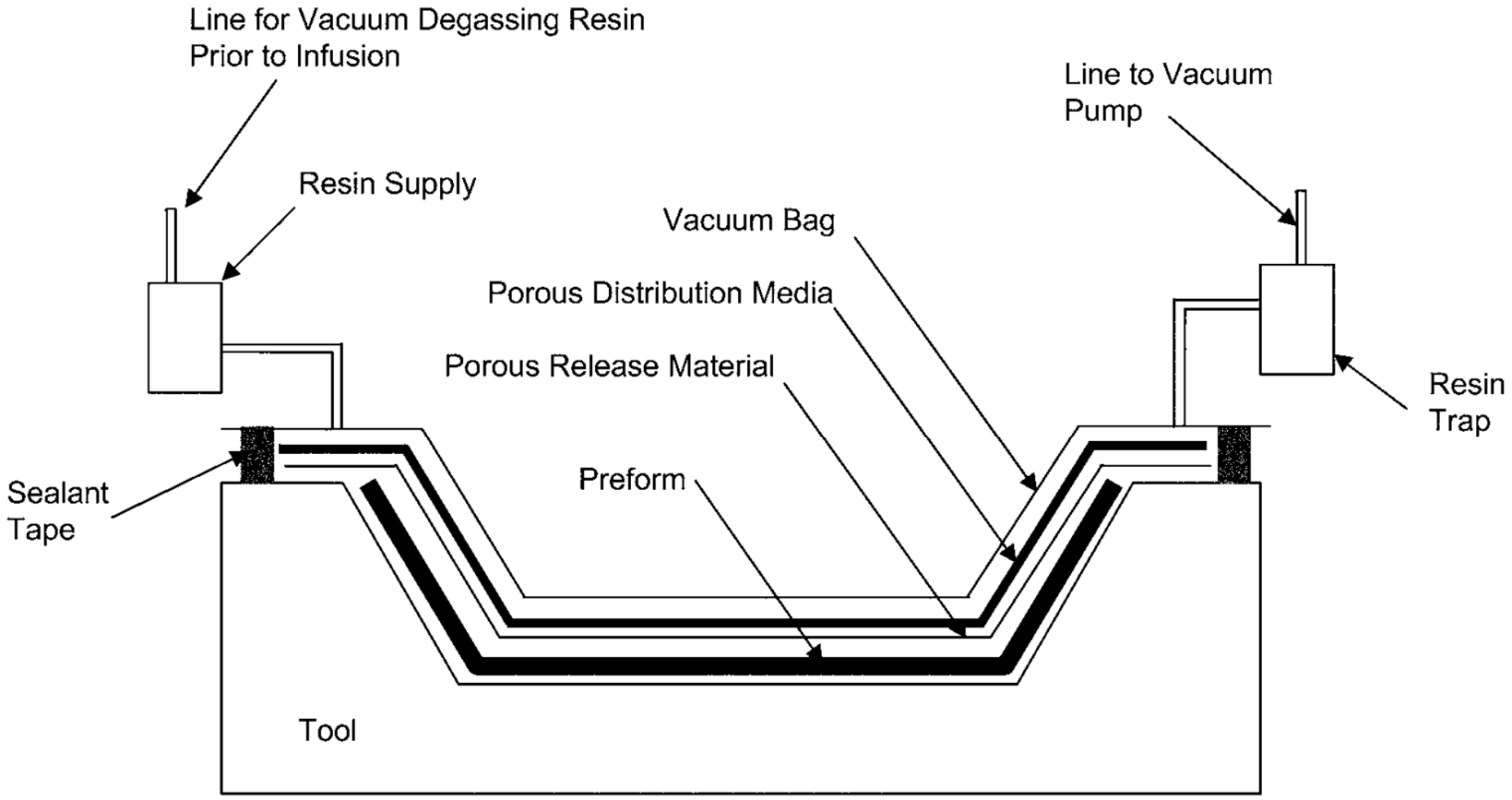
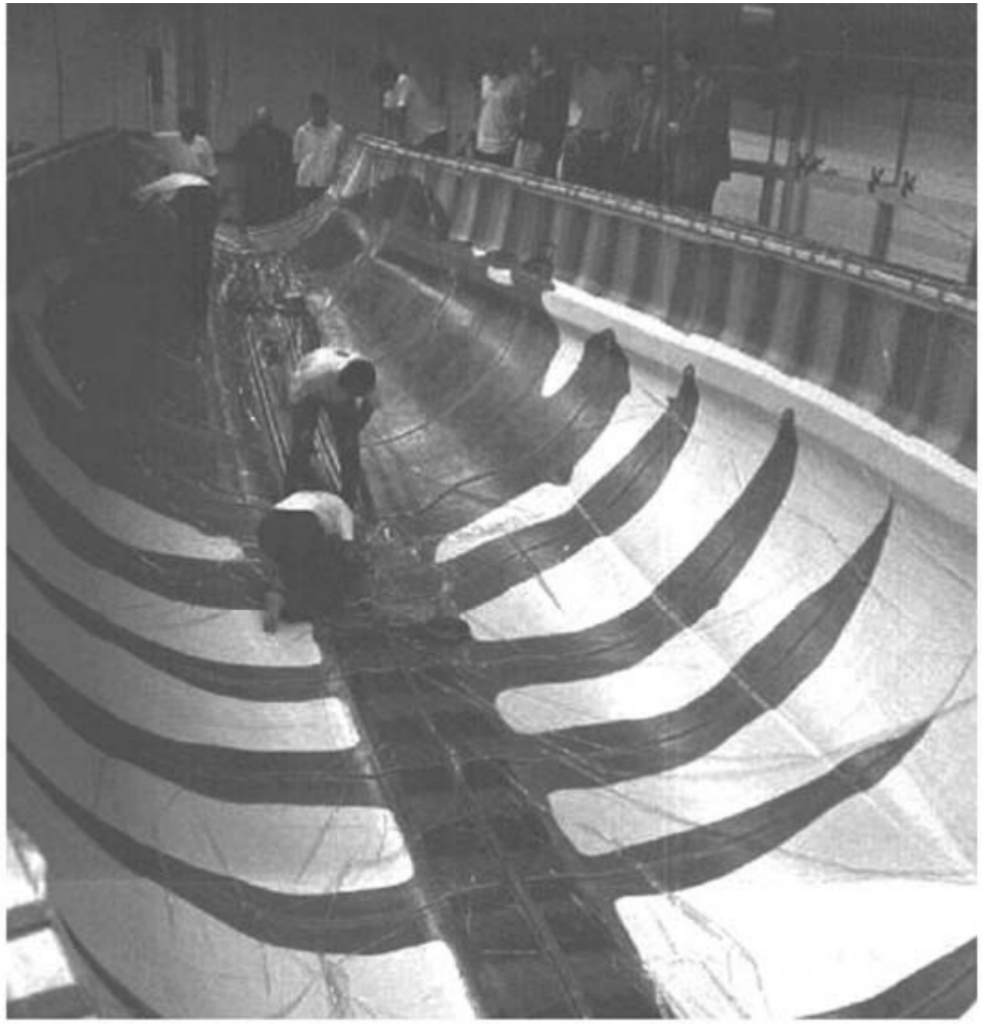


Fig. 5.52 Typical vacuum-assisted resin transfer molding (VARTM) process setup

Vakum Destekli RTM



Note the locations where the resin has wetted the preform, indicating the use of multiple injection ports.

Fig. 5.51 Vacuum-assisted resin transfer molding (VARTM) of a large boat hull

Vakum Destekli RTM

https://www.youtube.com/watch?v=yTsXKGUdtCE

Pultrüzyon – Levha Çekme Yöntemi

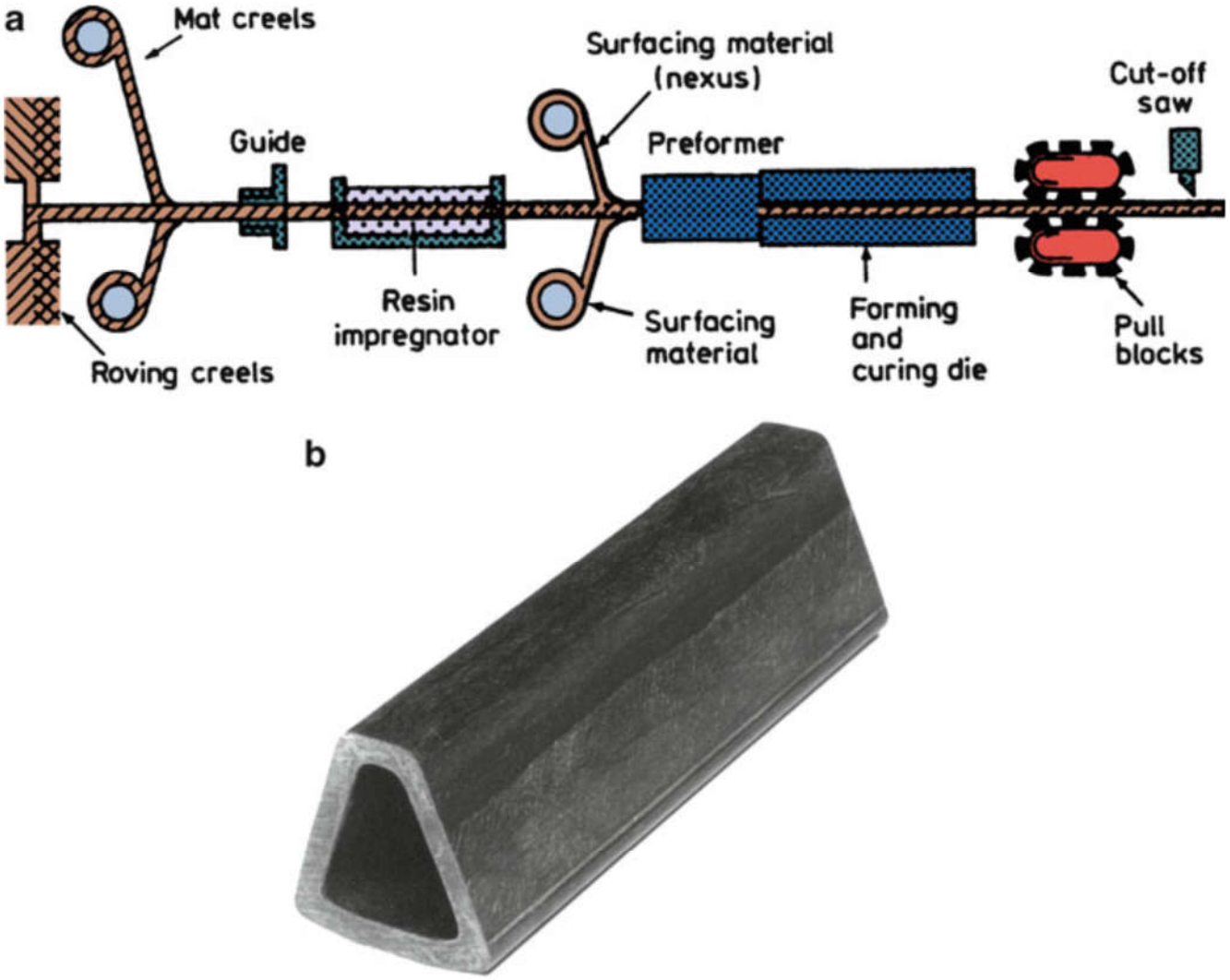


Fig. 5.3 (**a**) Schematic of the pultrusion process (courtesy of Morrison Molded Fiber Glass Co.). (**b**) A helicopter windshield post made of carbon fibers/vinyl ester resin by pultrusion. The post is 1.5 m long (courtesy of Morrison Molded Fiber Glass Co.)

Pultrüzyon – Levha Çekme Yöntemi

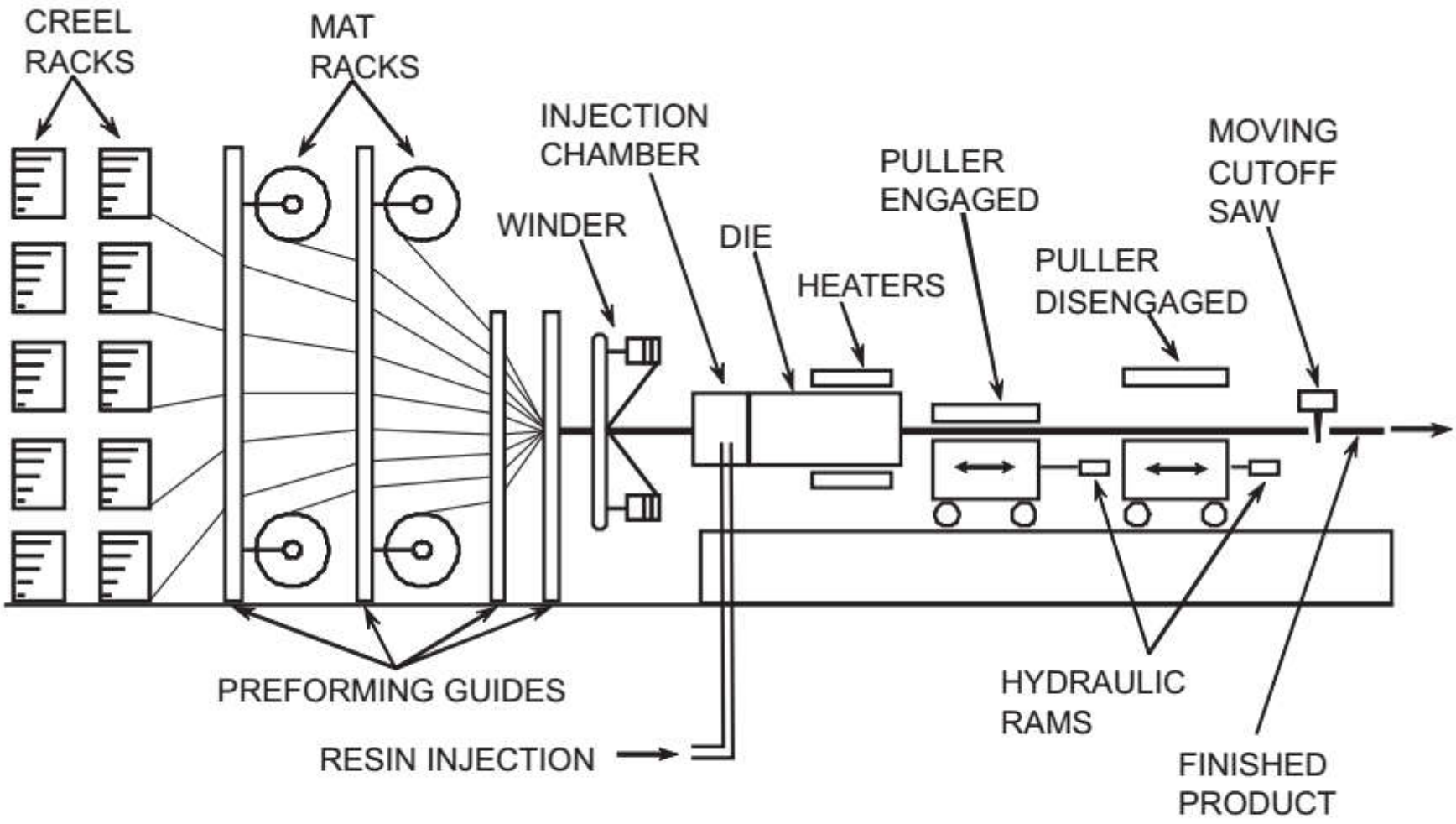


Figure 3.6: Pultrusion.

Pultrüzyon – Levha Çekme Yöntemi

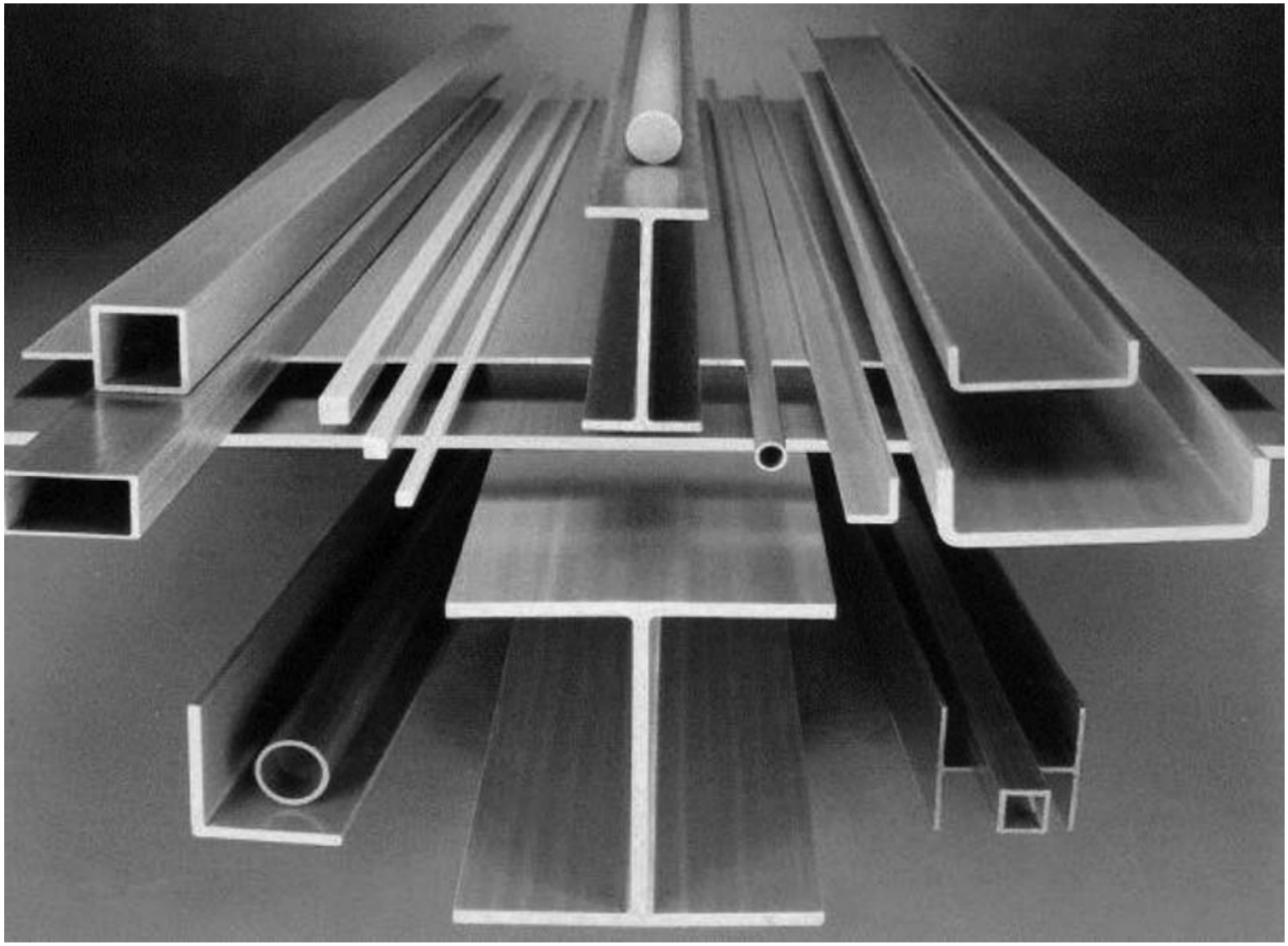


Fig. 5.59 Pultruded parts

Pultrüzyon – Levha Çekme Yöntemi

https://www.youtube.com/watch?v=1sH9rIGWNvc

Pultrüzyon – Levha Çekme Yöntemi

https://www.youtube.com/watch?v=aXq1hrzne2k

Basınçlı Kalıplama Yöntemi

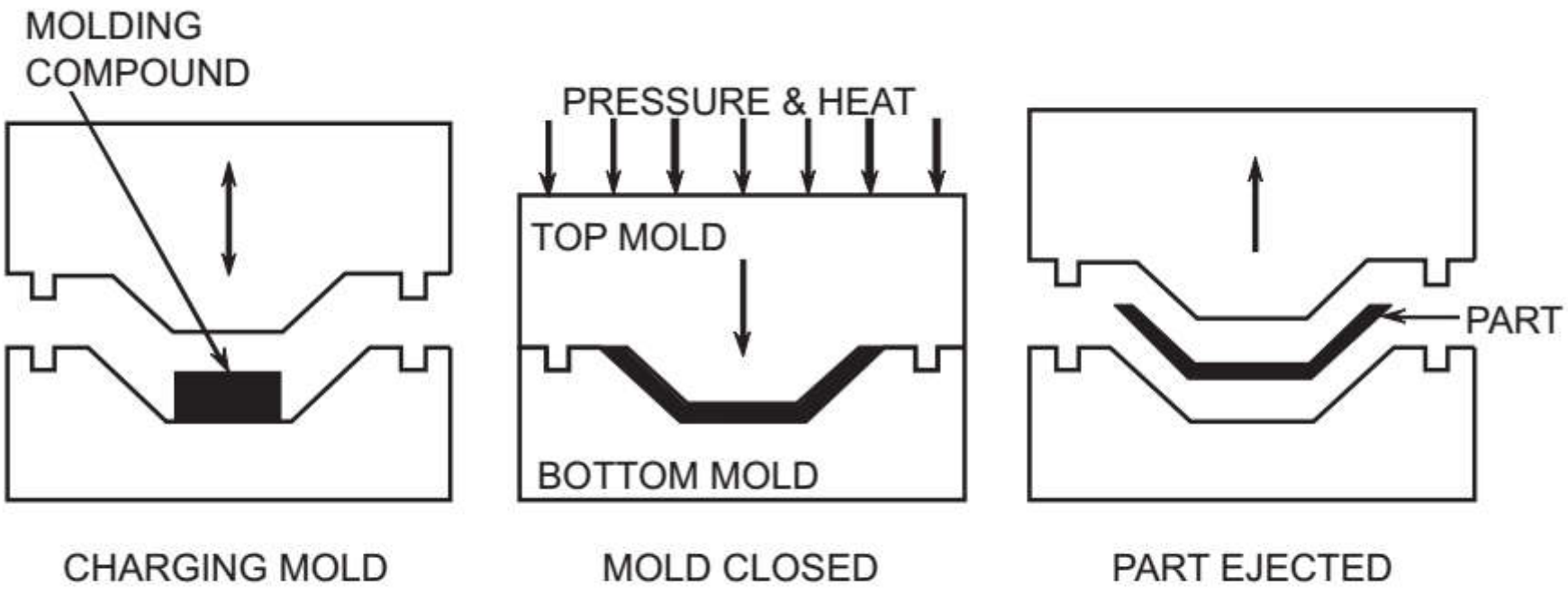


Figure 3.3: Compression molding.

Kaynaklar:

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