

Design of N95 Respirator using SMP

(SMP=Shape Memory Polymer)

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Introduction:

Considering the current Covid-19 pandemic, the demand versus supply chain of respirators for the doctors and general public are not met. Therefore, we have to come up with the new ways of building the respirators with long reuse cycles.

Any respirator decontamination process shouldn't compromise the proper fit, while maintaining its filtration efficiency.

In 2009, National Institute for Occupational Safety and Health showed treating the used respirators with H₂O₂ Vapour, UV Light, Dry heating (<100°C) doesn't affect the ability to filter the viruses & other harmful particles.

Limitation to the existing N95 Respirators:

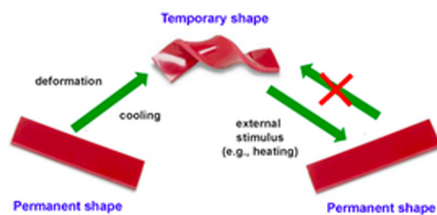
Cannot exceed 20-30 cycles of decontamination without affecting the fit of these respirators.

What is the Solution?

We embrace the standard N95 respirators with SMP.

What is a Shape Memory Polymer (SMP)?

Shape-memory polymers are polymeric smart materials that have the ability to return from a deformed state to their original shape induced by an external stimulus, such as temperature change. Here, we are using "DiAPLEX", based on Polyurethane developed by mitsubishi heavy industries in 2010.



Size?

Filaments of size 50d,70d are used, they are also commercially available making it easy to adapt by any firm.

How does it work?

When exposed to heat for decontamination, the DiAPLEX braced with the filter regains its original shape at 75°C (75°C because the blanket warmers in hospital work at this temp), thereby returning to the fit like a new respirator. Compared to the other two decontamination method, this has an edge as it increases the mask life and helps to flatline the demand vs supply curve.

How to incorporate in the Mass Production?

The Production line follows the standard production path of N95 Respirator. Except an additional step adds where the DiAPLEX is industrial glued to the mask. (Not stitched because it can affect the filtration Capacity)

Results:

Extended reusability- Hundreds of cycles are possible, as long as the respirator is not subjected to a melting temperature of, $T_{melt} = 180^{\circ}\text{C}$. (which is not practical as the respirator's limit is 100°C .) There's neither discomfort to the user nor the material is toxic.

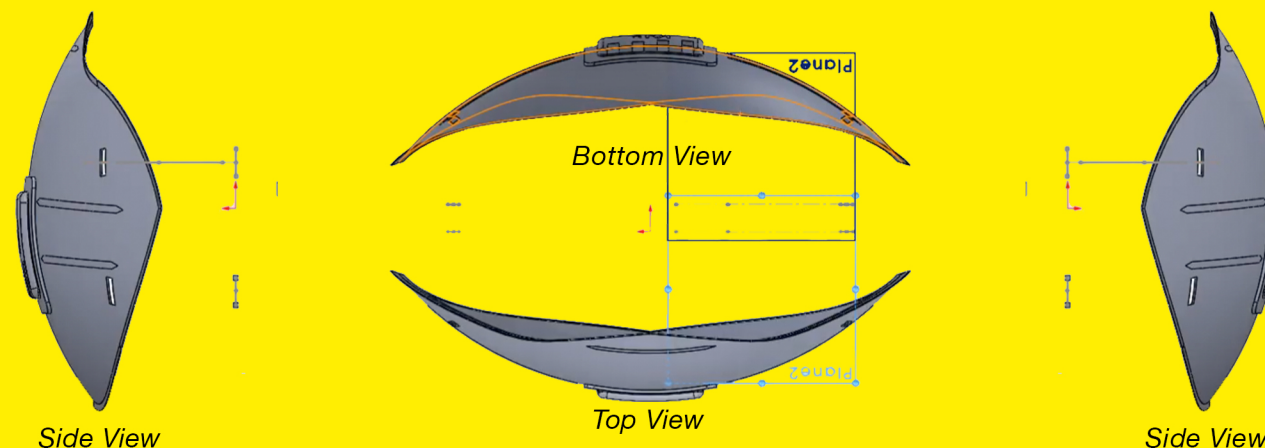
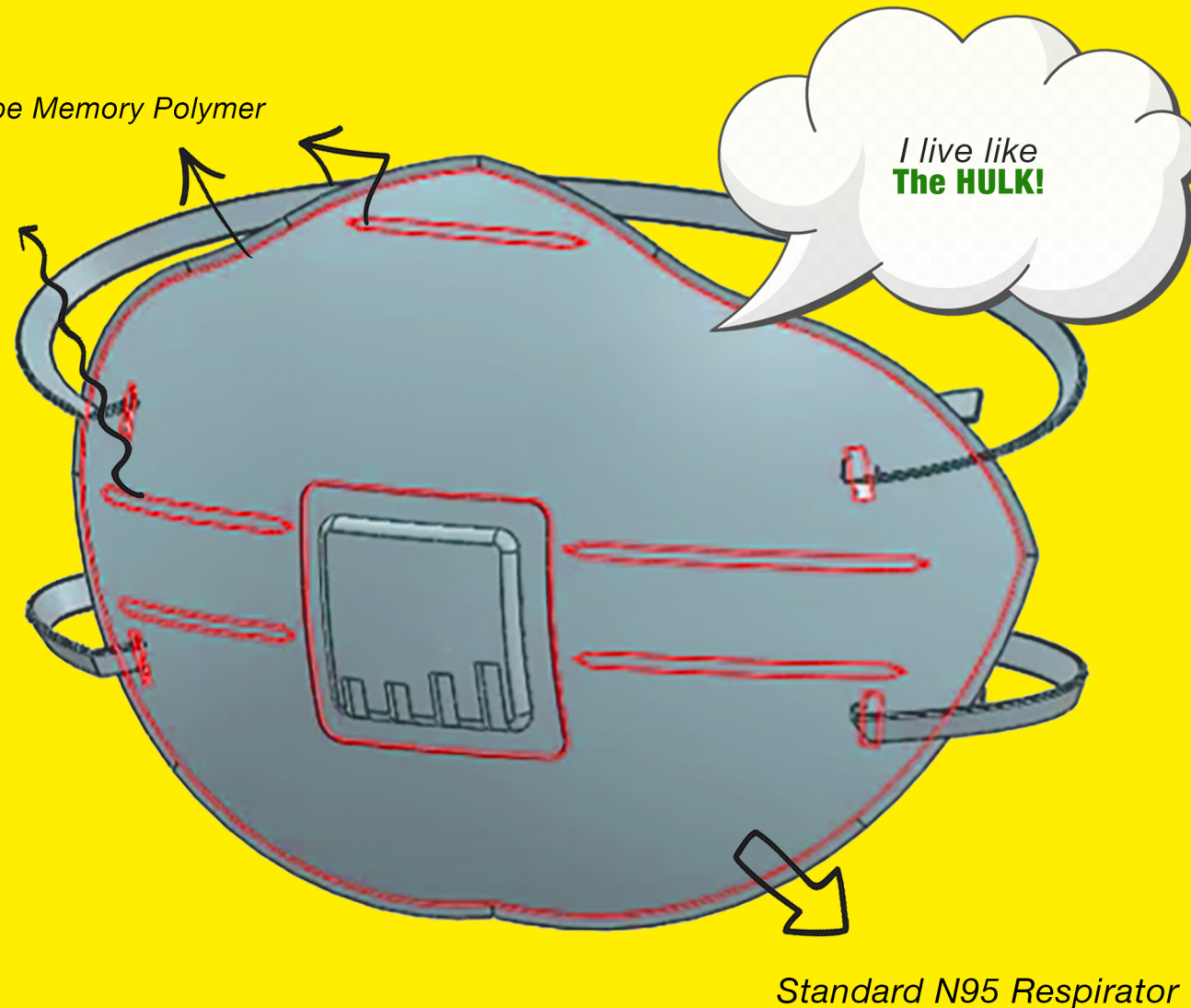
Mass Production is achievable pertaining to minimal extra costs which come in with the addition of the SMP. Value for money



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This Respirator can remember Things

Shape Memory Polymer

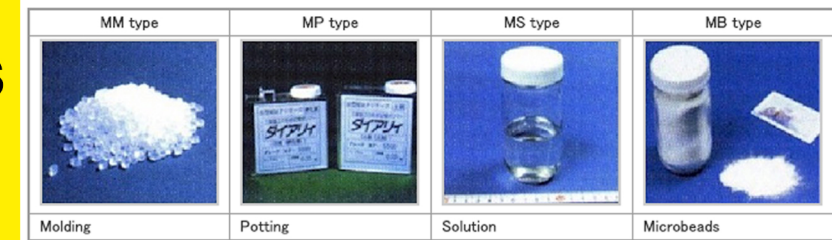


Technical Details

Molding Ability of DiAPLEX

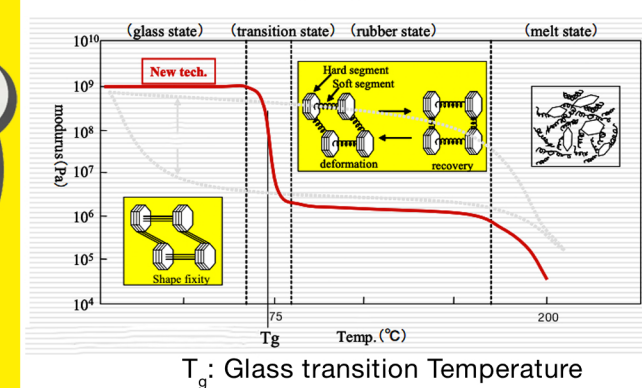
Forming techniques include Injection or extrusion.

Index	Material	Molding	Packing unit
MM	Pellet	Injection-Extrusion	20Kg Bag
MP	Resin & Hardener	Potting	1Kg Can x 2
MS	Solution	Coating	4Kg Can



More practical research required to select the appropriate molding for this application*

Elastic Modulus Property

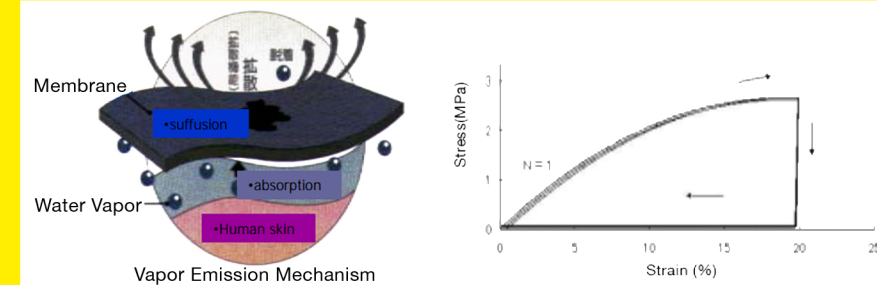


Because the transition state is around 75°C it is perfect for blanket warming ovens in hospitals.

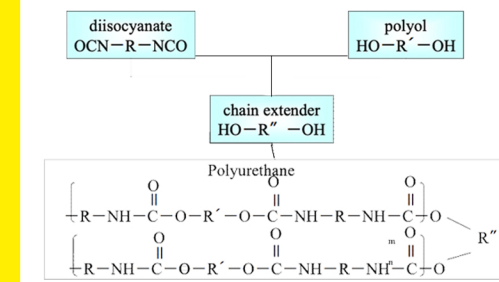
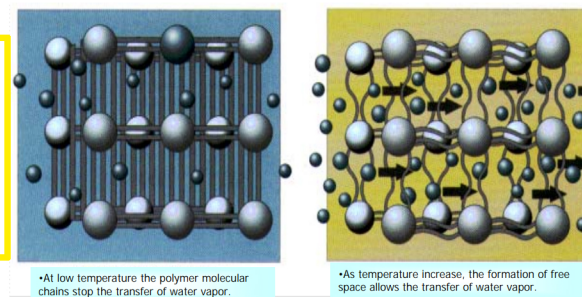
Shape Recovery and Rigidity

At a temperature higher than the Tg, SMP can easily change forms on application of low stress.

The maximum strain on SMP can be increased upto 400% by using DiAPLEX.



Micro-Brownian motion allows the nonporous polymer membrane to transfer molecules of water vapor only during decontamination



Can this cause suffocation?

It is breathable while keeping the moisture locked at ambient temperature.

Toxic/ Dangerous for the user?

DiAPLEX has been authorized in Japan by,

- 1.Regulation standard on Food and Food additives.
- 2.Food Hygiene law.
- 3.Japanese Ministry of Health and Welfare notice No.370 in 1959.

The pharmaceutical affairs law No.145 in 1960,Article14,section 1.