Polymeric Heart Valve (PHV) prostheses aim at combining the hemodynamic advantages of biological valves with the durability of mechanical valves [1]. Styrene Block Polymers (SBPs) appear as the best materials to this purpose, because of their excellent biocompatibility, chemical stability and fatigue resistance. In addition, these materials can be processed by injection moulding, a technique that allows controlling the alignment of the polyethylene micro chains [2,3] with the purpose to replicate the same circumferential orientation of the fiber of collagen in the natural heart valve leaflets (Fig.1). The aim of this work is the investigation of the micro domains orientation within the PHV leaflets produced by injection moulding technique in order to optimise the PHVs manufacturing.

Materials and Methods

In order to evaluate the polyethylene micro chain orientation during the injection moulding technique, a numerical model was developed. Numerical steady fluid dynamic simulation of the injection moulding of the valve were performed using ANSYS Fluent (ANSYS Inc., Canonsburg, PA, USA) with hexahedral elements mesh. Only one third of the valve was considered due to the valve’s geometric periodicity ($120^\circ$) (Fig. 2). Different polymer outlets (Fig.3a), inlets (Fig.3b) and flow rate have been simulated to investigate the best configuration leading to a predominantly circumferential orientation of the polymer chains.

The rheology of poly-(Styrene-Isoprene-Butadiene- Styrene) containing 19 wt\% styrene at 160 °C was described by the Carreau Model (1).

$$\eta = \eta_\infty + (\eta_0 - \eta_\infty)(1 + \gamma^2\lambda^2)^{(n-1)/2}$$

(1)

The parameter used to describe the Carreau Model are reported in Tab.1 while Fig.4 show how this model well fits the experimental data.

Results and Discussion

Different injection inlet/outlet were simulated with the same mass flow rate equal to $5.3\cdot10^4$ kg/s. In the leaflet, no significant effects on the streamline were obtained (Fig.6).

The differences in the polymeric chains orientations resulted negligible and for that reason the results obtained in the configurations shown in Fig. 7 are representative also of cases not reported. Modelling prediction of the S1BS19 microstructure averaged in the thickness of the leaflets show a micro domains mainly in the circumferential orientations (Fig. 7).

Furthermore, even if the phenomena that leads the polymer chains orientation is the same, differences in the orientation directions were seen among the point located near the mould walls (30 μm) and the ones at the middle of the leaflet thickness (Fig.8).

**References**

