Hairiness affects the post-spinning processes and fabric appearance. In order to reduce the yarn hairiness, the present work attempted to design and develop an air nozzle that can be easily attached on to the sirospun spinning system. The system, based on a nozzle attachment to the sirospun spinning system, is named the siro-jet. In our previous studies, the nozzle was used in ring and compact spinning processes and the changes in yarn properties were analyzed. In this study, various nozzles having different injector angles, main hole diameters, injector diameters, number of injectors, nozzle shapes and injector positions were used and siro-jet yarns were produced at different air pressure levels. At the end of the experiments, it was determined that there is an optimum value for each nozzle parameter, and that the number of injectors and injector position play the most important roles in reducing yarn hairiness, whereas nozzle shape shows the weakest effect. On the other hand, the findings showed that it is possible to get lower hairiness values by different modifications on the same nozzle design. Considering the hairiness results, a constant was defined indicating the relationship between nozzle structural parameters and hairiness of the yarns to ease the nozzle design efforts. Depending on nozzle type, the siro-jet spinning system truly improves the yarn hairiness by 40–75%. In the literature, many researchers used an air nozzle in the spinning and also the winding processes. However, the combination of the air nozzle and sirospun spinning system in this manner is still not a common application.