

CFD simulation analysis of pneumatic splicer

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Abstract: Pneumatic splicing is the widely used method to join the yarn without a knot using compressed air. The function of the pneumatic splicer is to untwist and retwist the overlapped yarn ends. As the compressed air is playing vital role in pneumatic splicing, to study the effect of air flow pattern and velocity of the compressed air applied on the yarn body is equally important when compared with the study of splicer related parameters and yarn related parameters for better splicing performance. Computational fluid dynamics (CFD) is the right tool to analyse the airflow pattern and the behaviour of yarn body under the influence of compressed air. Therefore, Solidworks CFD software was used to study the compressed air flow pattern and simulation of the behaviour of yarn body when it comes to contact with high pressure air. The airflow pattern during untwisting and retwisting has been studied in detail and given in this study. In addition to that, simulation of the yarn body during untwisting is also studied. Also the airflow equilibrium during retwisting has been studied.

1 Introduction

Splicing has become an inevitable process in the production of knotless yarn. Though there are different splicing methods, the pneumatic splicing become widely popular due to its versatility and performance. It is simple to describe the working principle of the pneumatic splicer as it performs only untwisting, overlapping and retwisting. However, it is really a tough challenge to achieve the proper splicing as it has huge number of variables with respect to device, air and yarn characteristics. As this pneumatic splicing technology is been an established technology and in industry for long period, many research activities was carried out and reported. Most of these studies were focused on yarn related parameters [1–4] and device related parameters [4–8]. Somehow the air and air flow pattern had not been studied much. However, Zhou and Qin [9] say that the computational fluid dynamics (CFD) analysis is an effective method for studying the splicing chamber. It is equally important for the performance of the splicer.

When it comes to compressed air, the air pressure, flow and time are the widely used variables. However, with respect to the application of compressed air in the splicers, the compressed air is basically used to rotate the yarn body to untwist and retwist [9]. Therefore, the angle and velocity in which the compressed air discharged on to the yarn body is most important for proper untwisting and twisting. The CFD is the vital tool to analyse the flow pattern and velocity of the compressed air. In addition to that, advanced CFD software is capable of simulating the rotation of the yarn body by the angular flow of compressed air [10].

Necessary three-dimensional (3D) models have been created and CFD software has been used for this simulation. Simulation study of both untwisting (i.e. preparation) and retwisting (i.e. overlapping and joining) is given in this paper.

2 Materials and experimental method

This simulation analysis has been conducted using Solidworks CFD simulation software. The necessary 3D models have been developed under Solidworks 3D platform, as shown in Figs. 1 and 2. The dimensions of the 3D model including the nozzle and its position are appropriate to the working model of a pneumatic splicer. The pressure of the compressed air is kept constant as 6 bar and the fibre density is given as 1.54 g/cc during the simulation process.

Results of the simulation analysis include the compressed air flow direction and its behaviour across the untwisting tube and

retwisting compartment with velocity plot gradient and air velocity plot across the unwinding tube and retwisting compartment. Also an attempt has been made to simulate the yarn behaviour during untwisting under compressed air flow. Being simulation study, there is no real yarn and mechanism has been used to splice and find the performance of the splicer.

3 Results and discussion

3.1 Study of untwisting

During splicing process, initially the yarn from both packages are being cut and clamped by mechanical means. The untwisting is carried out immediately after clamping with pneumatic pressure flow. Usually a splicer has two untwisting positions, one near top

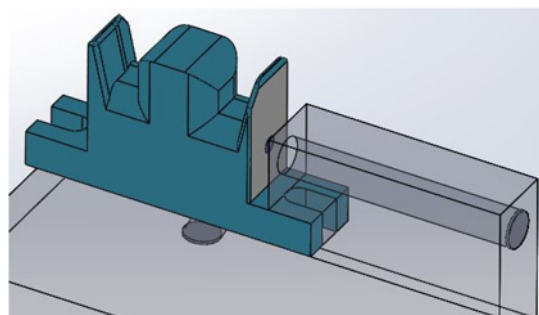


Fig. 1 Untwisting nozzle and untwisting tube

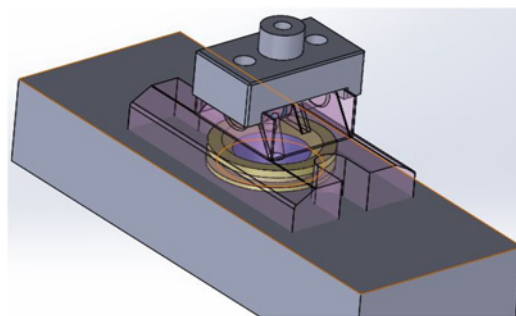


Fig. 2 Retwisting compartment with lid

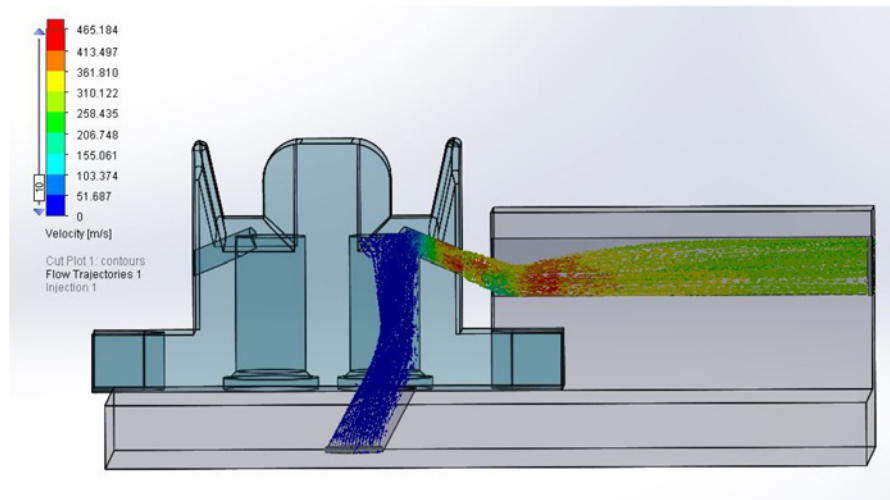


Fig. 3 Front view of the untwisting airflow

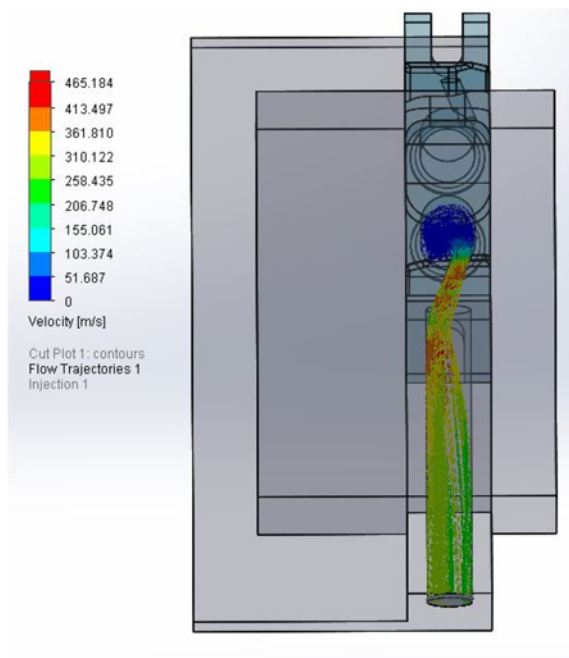


Fig. 4 Top view of untwisting airflow

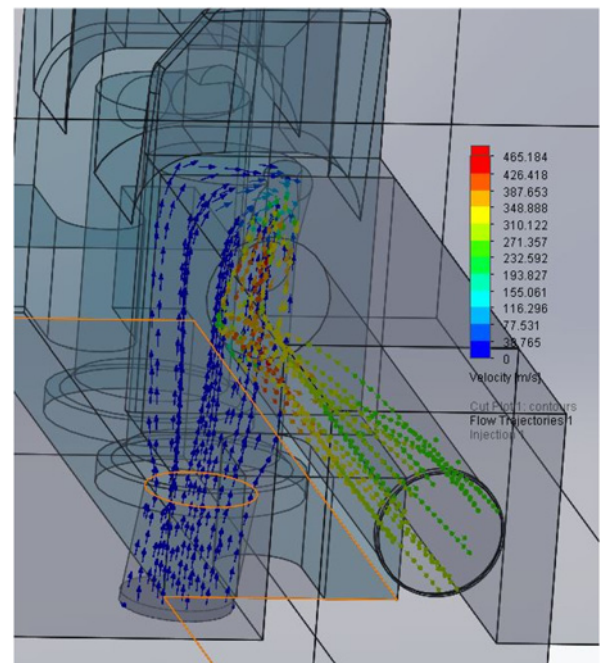


Fig. 5 3D view of untwisting airflow

end the other near bottom end. The top untwisting position untwists the yarn from bottom package and vice-versa. The untwisting is achieved by rotating the yarn in opposite to the direction of twist. In addition to the rotation given to the yarn body, the turbulence created by the pneumatic current will remove the twist since it is an open yarn end. The excessive air flow and air velocity make the fibres to fly and the insufficient airflow will not untwist the yarn.

Figs. 3–5 are the pneumatic simulation of the air passing through the untwisting nozzle and untwisting tube. With reference to Figs. 3 and 4, it has been observed that the entire air is focused into the untwisting tube without wastage. As the air is passed through a relatively small hole, the velocity of the air is in the ranges between 200 and 450 m/s. Also the air is made to enter into a corner of the untwisting tube to create a torque for rotating the yarn in opposite to twist direction. For better understanding, a simulation photograph with less dense lines is given in Fig. 5 to explain the whirling effect created by the pneumatic current.

Above all, the real strength of the CFD analysis is it can simulate the real-time application in addition to air flow. In this case, the splicer is used to join the yarn by untwisting and retwisting. The simulation of yarn passing through the untwisting tube is shown in Figs. 6 and 7. This gives an idea about how many revolutions the yarn is going through. It is very much useful to freeze the nozzle diameter, angle of nozzle and untwisting tube diameter. This is the most important feature of simulation which makes the right at first time during the development process.

3.2 Study of retwisting

Retwisting is the final but critical operation of the splice cycle. After untwisting, the overlapping length is adjusted as per the setting by retracting levers and the chamber will be closed. Subsequently, the air jet is passed through the nozzles to create whirling and fibre mingling. The nozzles are placed in such a way that they are facing diagonally opposite to each other and having similar angle of inclination. Therefore, these nozzles

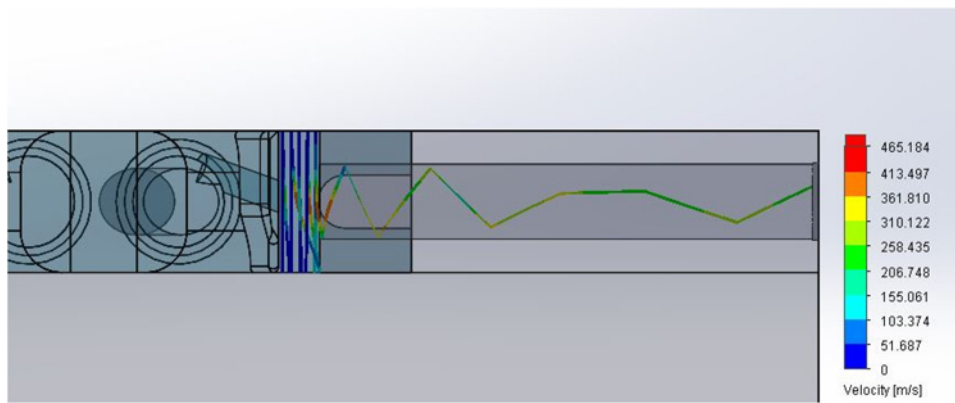


Fig. 6 Side view of the yarn passing through untwisting tube

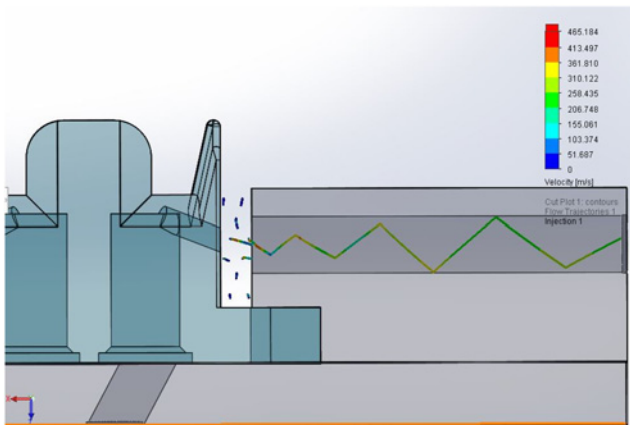


Fig. 7 Top view of the yarn passing through untwisting tube

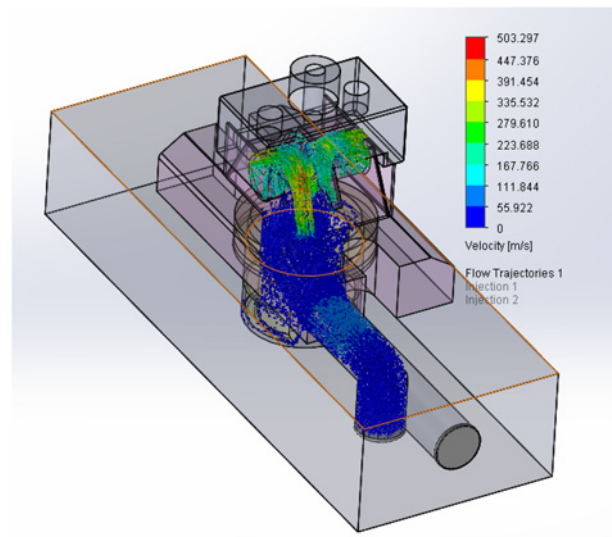


Fig. 8 3D view of retwisting airflow

create twisting torque on the untwisted yarn. Fig. 8 shows the simulated air flow pattern on the twisting compartment in 3D view. Fig. 9 illustrates the end view of the same simulated air flow into retwisting compartment. More than 300 m/s velocity is required to rotate the yarn body for twisting. After twisting the yarn, the air escapes through the hole which is used for the entry of the yarn.

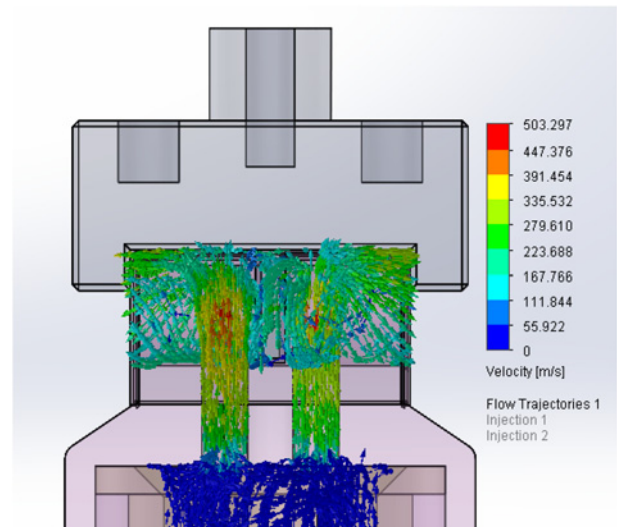


Fig. 9 Side view of retwisting airflow

The velocity plot is a critical tool to optimise the retwisting nozzles. It is obvious that two nozzles are placed opposite to each other with same degree of angle which will create whirling effect on the overlapped yarns. The difference in velocity found in these nozzles will affect the whirling effect and resulting poor splicing performance. As these two nozzles fed by a common compressed air supply, so there is good chance of unequal air flow in these nozzles which affect quality of splicing. Also it is very difficult to identify. However, the CFD software can perfectly simulate the velocities and flow on each nozzle. Fig. 10 shows the velocity plot of the retwisting compartment nozzles which are found equal in velocity distribution. In this case, the air flow in both nozzles is found approximately equal. However, in order to achieve this equilibrium, several iterations with modifications had been gone through in the 3D model stage itself. Therefore, it was good to achieve the expected result in the very first sample prototype.

4 Conclusion

Performance of the splicer is largely depending on the compressed air components namely pressure, flow and time. CFD software is the right tool to study and analyse the air flow pattern and velocities. Moreover, the sophisticated features of the CFD software like simulation of behaviour of foreign bodies under the given flow is very much helpful to understand the level of whirling happening during untwisting and retwisting operations. CFD analysis and

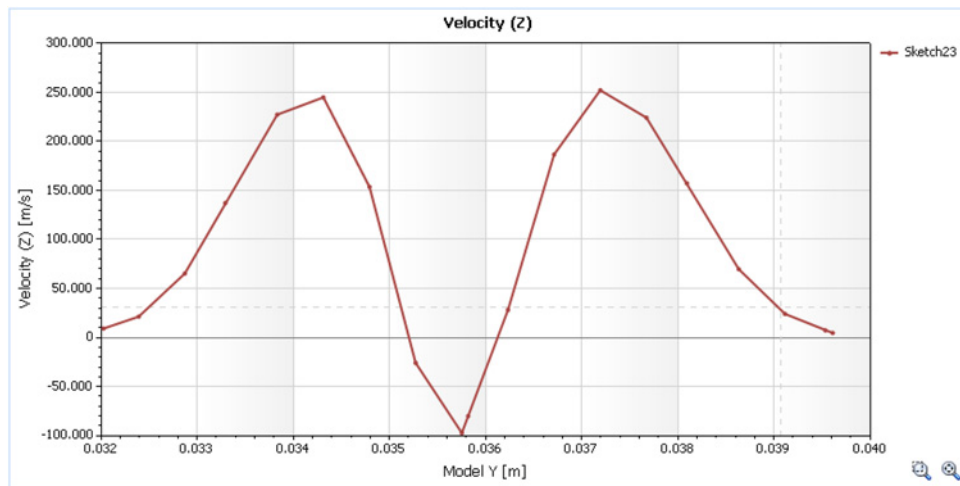


Fig. 10 Velocity plot of two nozzles in retwisting compartment

simulation is right tool to develop such pneumatic intensive products right at first time.

5 References

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