Deflector Optimization of Flow Field in 90°Elbow

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Abstract. In this paper, fluent numerical simulation is used to solve the air flow in the 90 bend pipe with RNG $k-\varepsilon$ epsilon model. The vortex and the secondary flow loss in the bend can be greatly reduced by adding a proper deflector. In this paper, 7 deflectors are respectively arranged along the radial direction of the elbow. According to numerical simulation, we find the flow of a single 90 degree guide plate at the 2# position (0.5D) is best. The loss is reduced by 39.7% compared to the pressure drop without adding any deflector.

1. Introduction

The pipeline system is widely used in the industrial field, and bend is a normal component in the pipeline system. Due to the dramatic changes in the state of the fluid movement in the pipe, the vibration of the pipeline is not stable, and there will be a partial loss, which cannot be underestimated [1]. Today we advocate energy saving, so it is of great significance to study the loss of flow at bend. Installing a suitable deflector in the elbow can not only stabilize the system and reduce the abrasion of the pipeline, but also make the velocity of the fluid even and reduce the loss of energy [2].

In this paper, we will use the knowledge of fluid mechanics and fluent numerical simulation to analyze and design the deflector, so as to minimize the energy loss in the bend.

2. Model hypothesis

(1)The material of the deflector and pipe is even and they have uniform thickness.

(2)The fluid flow in the pipe is three-dimensional steady turbulent flow, and we think it does not change with time.

(3)We do not consider frictional losses in fluid flow.

3. Original Model

The pipe dimensions are as follows: It consists of two straight pipes and one elbow. The fluid is air. And the inlet velocity is 10 meters per second.

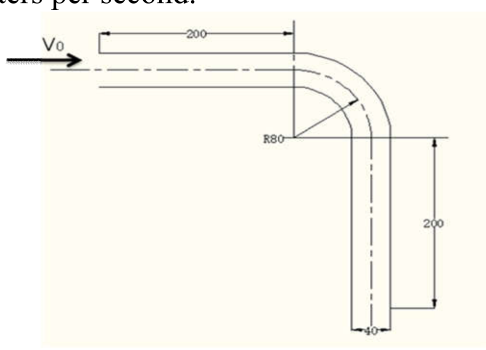

Figure 1. Original pipe

Through the FLUENT software simulation, the mesh is divided as follows:

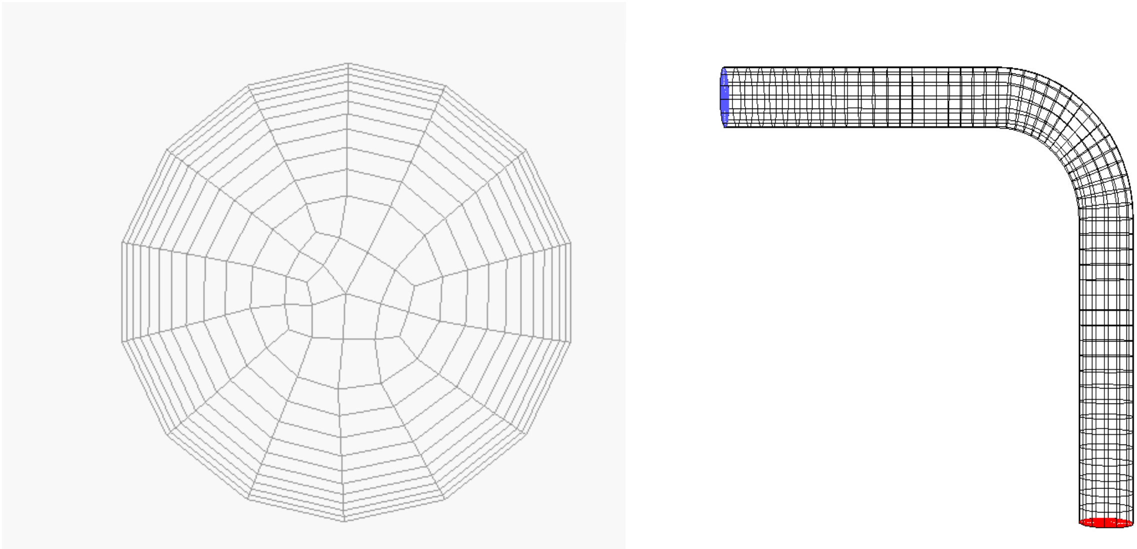

Figure 2. Mesh of the pipe

The results are as Table 1:

Table 1. Results of original pipe

Fluid	Inlet velocity	Temperature	Re	Δp	v_{max}
Air	10 m/s	300K	2.56×10^5	14.771Pa	10.1697m/s

The pressure nephogram and velocity nephogram are as follows:

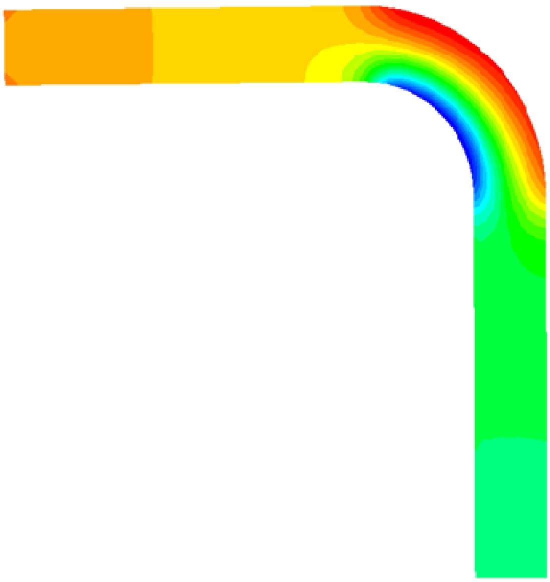

Figure 3. Original pressure nephogram

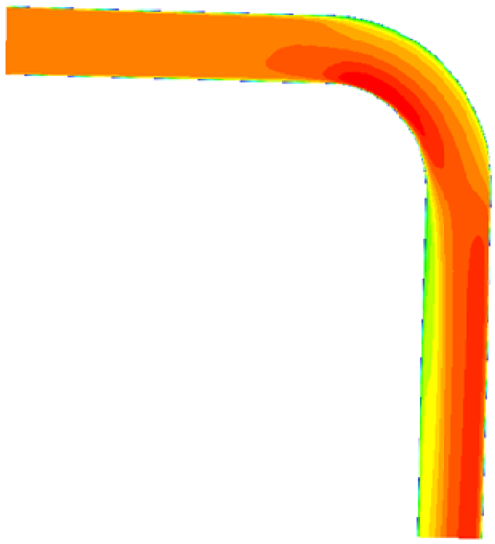

Figure 4. Original velocity nephogram

4. Optimization Model of the Guiding Plate

Based on the original model, by adding different locations of the deflector to improve the flow state, thereby reducing the flow through the bend of the local loss Along the elbow, the bent pipe is divided into eight parts, and a monolithic guide plate is arranged in corresponding position of the 1#-7# for a single chip calculation.

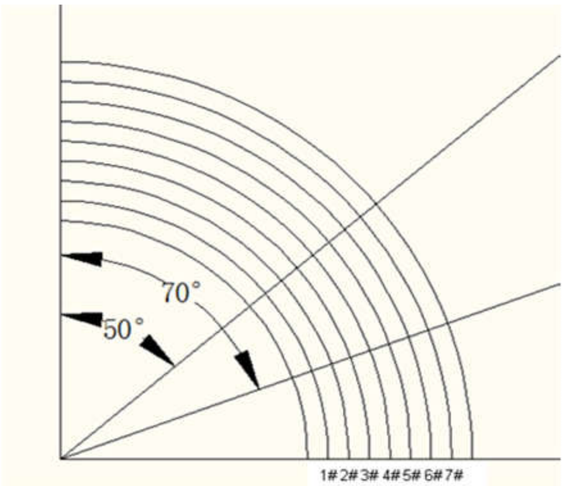

Figure 5. Different locations of the deflector

Under the same conditions, the results are as follows:

Table 2. Results of different locations

Location	1	2	3	4	5	6	7
Δp (Pa)	9.0134	8.9071	9.3827	9.9537	10.1766	10.276	10.3502
$v_{\max}$ (m/s)	10.0297	10.0266	10.0327	10.1065	10.0985	10.0808	10.0847

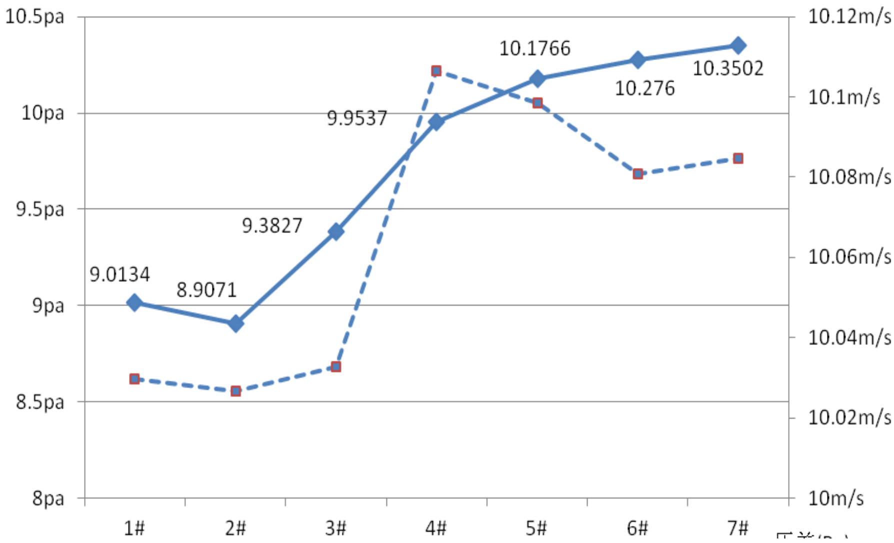

Figure 6. Result comparison

From Table 2 and Figure 6,we can know the best scheme to improve flow distribution is 2#. Figure and Figure show its pressure nephogram and velocity nephogram.

According to the pressure nephogram and velocity nephogram, we can see that the flow field is obviously homogeneous, and the range of low pressure region and high pressure zone is obviously reduced. The effect of uniform flow field is great.

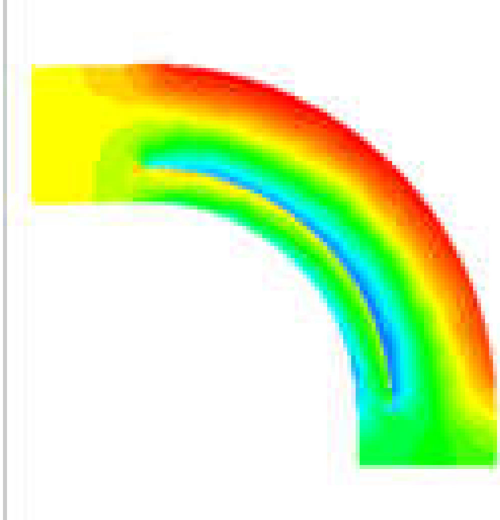

Figure 7. 2# pressure nephogram

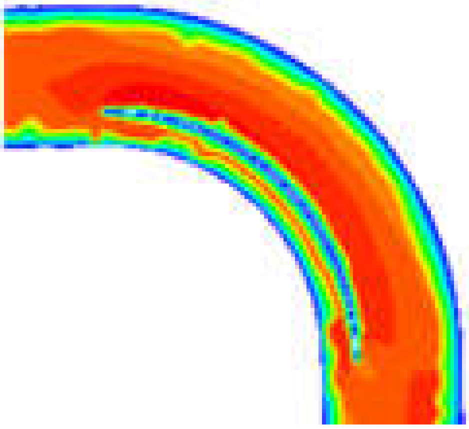

Figure 8. 2# velocity nephogram

5. Results of the Model

Δp is used as a measure of fluid flow loss. If Δp is greater, the loss is greater. The fluid flows through the elbow with a radius of curvature of 80cm and a diameter of D 40cm. The pressure drop Δp is 14.771Pa. v_{max} Appears at the inside diameter of the elbow, and it is 10.1697m/s.

We use Δp as a measure of flow loss. According to the simulation results above, it can be seen that the flow loss is reduced to a certain extent under the action of a single baffle plate. The flow of a single 90 degree guide plate at the 2# position is best, and the minimum pressure drop at this time is 8.9071Pa. The loss of 14.771Pa is reduced by 39.7% compared to the pressure drop without adding any deflector. This shows that adding the deflector at the proper place at the elbow can reduce the loss due to uneven flow to a certain extent. The length of the 90 degree deflector is relatively long, and the restriction of the tail flow is stronger.

The deflector can guide the flow of the fluid because it divides the bend into multiple channels. The radius difference between the inner arc and the outer arc of each pipe is reduced, so that the inertia and the centrifugal force of the fluid are reduced, and the low pressure area of the high pressure area is effectively eliminated [3]. The flow field is distributed evenly.

References

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