Banana Jet

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By bending the air jet from a jet fan in a tunnel away from the restrictive surface (walls / ceiling) the performance of the fan in the system can be dramatically improved. This can be done with silencers or ducts which are bent with an angle of 5 – 25 %. The source of the improvement is that not only are the losses directly behind the fan virtually eliminated, but the airflow profile down-stream in the tunnel can be improved, further significantly reducing aerodynamic losses. The net result is a reduction of the required installed thrust by 30 – 50 %. Not only does this mean that far fewer (or smaller) fans need to be installed, but the installation cost for cabling, mounting etc. is also reduced in the same proportion. A 30 – 50 % reduction in required thrust directly translates into a reduction in energy cost in the same order of magnitude so there is a larger savings in operating costs in addition to the benefit of lower capital cost.

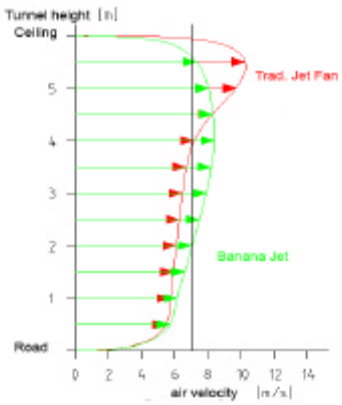

Fig.1

The use of Banana Jet can reduce these losses by 25 – 50 %, depending on the design of the tunnel. The physics behind this improvement is relatively straightforward:

Friction loss

An air stream that blows along a surface becomes “glued” to the surface due to the induced swirl and one-sided low pressure. This effect, called “Coanda-Effect” creates a less uniform flow in the tunnel, with larger velocities along the wall**)**

Background velocity correction

The energy that a fan gives to the air flow in the tunnel is a function of the difference in airspeed at the outlet compared to the speed of the air at the inlet of the fan. The higher the background velocity is around the fan, the less impulse can be transferred to the air streaming by the fan.
Due to the Coanda-Effect the actual air velocity around the down-stream jet fans is higher than it would be in a free field. The different airflow profile with Banana Jet means a slightly smaller correction factor is required. Measurements in various tunnels have shown a difference in airspeed around the fans of 10 – 20 %. A 3 – 5 % reduction in losses can be expected, more if the fans have to be spaced closely together. (Less than 100 m between the fans)

Impulse losses

10 – 20 % of total the thrust generated by traditional jet fans is lost right behind the fans as part of the air jet hits the surface the fans are mounted on with a high velocity (Fig. 1) due to friction and impulse losses. By bending the flow away from the surface this loss can be virtually eliminated. Since the losses are a fixed factor of the overall losses in the tunnel, so at least the above mentioned 10 – 20 % can always be avoided by using Banana Jet.

Losses in corners, niches and other installations.

Fans are generally hung outside the traffic area, typically in corners or niches of the tunnel. The same space is also used for lamps, road signs and other installations. Because the jet from a Banana Jet can be flexibly directed, the losses can be reduced, especially in corners and niches. (Fig. 2) Also, the jet can help overcome losses from bends, changes in diameter etc. The actual design of the tunnel must be analysed to estimate the improvement that can be achieved.

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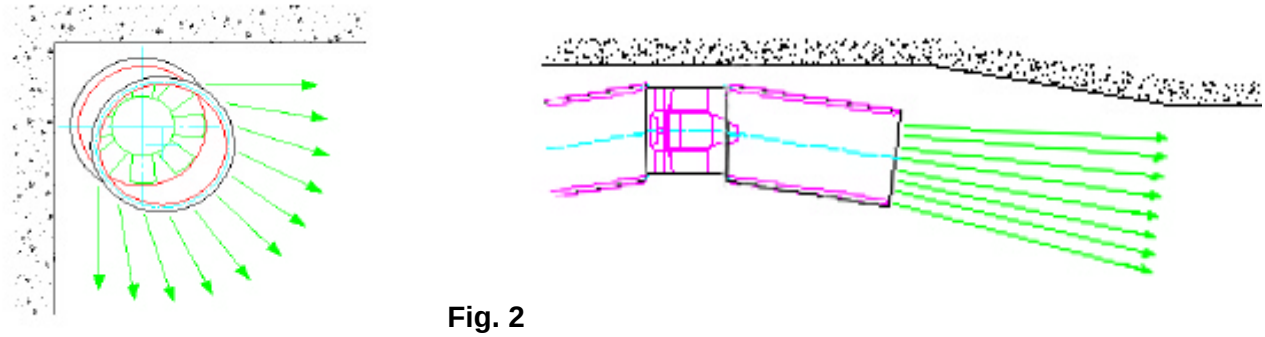

Fig. 2

Measurements

Banana Jet has been tested in 3 tunnels, 2 of which were measured by HBI Haerter AG, consulting engineers out of Zürich, Switzerland. For comparison purposes, the Banana Jet were converted into traditional jet fans by means of transition pieces removing the bend of the silencers. As can be seen from Fig. 3, the measurements confirm the expected results.

Fig. 3

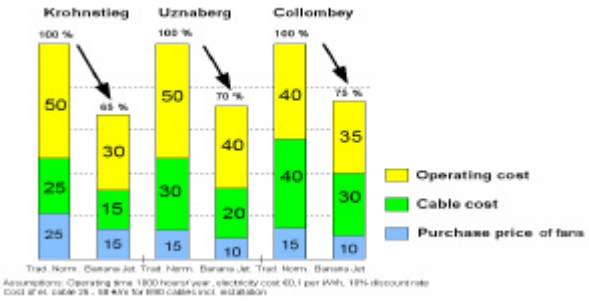

Fig.4

The Banana Jet produced a significantly higher airspeed in the tunnel. This is equal to a reduction in total losses of 24 – 32 % (i. e. an increase in thrust of 32 – 47 %) In all 3 tunnels further reduction in losses seemed possible if the directabilty of the jet had been further exploited e.g. by better countering the effect from bends, walls, lamps, etc.

Financial implications

A reduction in the thrust required to move the air in a tunnel has dramatic consequences for the general contractor and also the end user / tunnel operator.

- Fewer (or smaller) fans are required, proportional to the reduction in thrust required.
- Less cabling (or smaller cable cross sections) necessary. Often the total cabling cost incl. installation is more than the price of the fans.
- Less energy consumption / operating cost, proportional to the reduction in thrust achieved.
- Fewer (smaller) niches can be build.
- More flexibility in the choice of the fan locations.
- Ability to increase the volume flow rate in old tunnels by 10 – 20 %, without changing the cabling and power supply.
  Fig. 6 shows the effect that was achieved for the 3 tunnels measured by installing Banana Jet. Not only were the overall life cycle costs reduced by 25 – 35 %, but the capital costs were so much reduced that the savings were almost as large as the total price of the fans.

Conclusion

The use of the Banana Jet can reduce the installation and operating cost for longitudinal road tunnel ventilation significantly. An improvement of 25 – 50 % compared to traditional jet fans is realistic.

The improvement is in principle due to an aerodynamic adaption of the fans to their real purpose. Instead of aligning fans geometrically to the contours of the tunnel, the air flow is directed away from the tunnel walls, thus greatly reducing the losses.

One truly must ask: “Why did nobody think of this before?”