

Journal of Physics Special Topics

An undergraduate physics journal

P3 7 Water Breathing as Laminar Flow Control in Demon Slayer

B. Hunt, C. Raitt, D. Tyminski

Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH

December 1, 2025

Abstract

In the anime *Demon Slayer: Kimetsu no Yaiba*, “Water Breathing” is a fictional swordsmanship style characterised by fluid, almost effortless high-speed katana strikes, as though the blade moves through water rather than air. We model this aesthetic as a hypothetical active flow-control mechanism that enforces laminar boundary-layer flow over the blade at $Re \approx 10^6$. Using Blasius theory and drag coefficients, we calculate a 94% reduction in aerodynamic torque and a 45% reduction in muscular effort, making the blade *feel* approximately one-half lighter, whilst preserving strike impulse. In reality, turbulent transition occurs in $\sim 10 \mu\text{s}$ under adverse pressure gradients; sustaining laminarity at such Reynolds numbers is impossible without advanced actuators. This model quantifies the biomechanical basis for the “effortless flow” aesthetic in *Demon Slayer*.

Introduction

In the anime *Demon Slayer: Kimetsu no Yaiba*, demon slayers use stylised “Breathing Techniques” to enhance combat performance [1]. Among these, “Water Breathing” is depicted as a sequence of graceful, high-speed katana strikes executed with minimal apparent effort; the blade appears to slice through air as smoothly as through water, with fluid arcs and near-weightless control. This paper reinterprets Water Breathing not as mysticism, but as a fictional analogue to *active laminar flow control*.

We will estimate that the katana swings reach tip speeds of $v \approx 40 \text{ m/s}$ [2,3]. The flow regime is characterised by the Reynolds number

$$Re = \frac{\rho v L}{\mu} \quad (1)$$

where ρ is air density (1.2 kg m^{-3}), v is blade speed, L is the characteristic length of the flow,

and μ is the dynamic viscosity of air, $1.8 \times 10^{-5} \text{ Pa s}$ [4]. For a sword moving through air, the appropriate length scale is the blade length, $L \approx 0.7 \text{ m}$, giving

$$Re = \frac{(1.2)(40)(0.7)}{1.8 \times 10^{-5}} \approx 1.9 \times 10^6.$$

This exceeds the critical $Re_{\text{crit}} \sim 5 \times 10^5$ for boundary-layer transition [5], so real swings are turbulent.

The Blasius solution gives the laminar *skin-friction* coefficient for steady flow over a flat plate with zero pressure gradient[5]:

$$\bar{c}_f = \frac{1.328}{\sqrt{Re}} = \frac{1.328}{\sqrt{1.9 \times 10^6}} \approx 1.0 \times 10^{-3}. \quad (2)$$

This represents only viscous surface drag. A swinging sword, however, experiences an additional dominating *pressure drag* from its finite

thickness, leading edge, and cross-flow motion, so the effective drag coefficient is

$$C_D = C_f + C_{D,p},$$

where $C_{D,p}$ is the form-drag contribution. Experimental data for slender laminar aerofoils at $Re \sim 10^6$ indicates typical values $C_D \sim 0.05-0.1$ [6]. We therefore adopt a conservative total laminar value of:

$$C_{D,\text{lam}} = 0.07,$$

representing an idealised case where *Water Breathing* enforces perfect laminar attachment and suppresses separation.

Calculations

The governing equations for force due to drag and torque are:

$$F_D = \frac{1}{2} \rho v^2 A C_D \quad (3)$$

$$\tau_D = F_D r_c \quad (4)$$

Where r_c is the torque arm, and the centre of pressure is taken at $r_c \approx 0.4L = 0.28$ m for a uniformly loaded slender blade. For a uniformly loaded slender blade, the resultant aerodynamic force acts approximately 40% along its span from the handle, corresponding to the centre of pressure for a thin flat lifting surface.

Drag Coefficient Contrast

The turbulent drag coefficient $C_{D,\text{turb}} \approx 1.2$ (a typical value for certain bluff (blunt) bodies, such as a flat plate held perpendicular to the flow) includes skin friction and form drag due to early flow separation [6]. For laminar flow:

$$C_{D,\text{lam}} \approx 0.07.$$

Thus

$$\frac{C_{D,\text{lam}}}{C_{D,\text{turb}}} = \frac{0.07}{1.2} = 0.058,$$

representing a 94% reduction.

Torque Reduction

The projected frontal area, with blade chord (width) denoted by c , is $A = cL = (0.03)(0.7) = 0.021 \text{ m}^2$. Thus

$$F_D \approx 20.16 C_D \text{ N}, \quad \tau_D = 5.645 C_D \text{ Nm}.$$

For turbulent flow $\tau_{D,\text{turb}} \approx 6.77 \text{ Nm}$, whilst for laminar flow $\tau_{D,\text{lam}} \approx 0.40 \text{ Nm}$ [7]. Therefore the aerodynamic torque falls by 94%.

Perceived Effort

The muscular torque is $M = I\alpha + \tau_D$. With $I\alpha \approx 7.3 \text{ Nm}$,

$$M_{\text{turb}} = 14.07 \text{ Nm}, \quad M_{\text{lam}} = 7.70 \text{ Nm}.$$

Hence

$$\frac{M_{\text{lam}}}{M_{\text{turb}}} \approx 0.55,$$

so the muscular torque drops to $\sim 55\%$ of its unmodified value (roughly 45 reduction) in this extreme orientation - and optimistic fantasy upper bound .

Strike Impulse

The tip momentum $p = (I\omega)/r$ is unchanged for equal angular speed ω , but reduced aerodynamic torque allows higher sustainable ω within human power limits ($\sim 300 \text{ W}$) [8], enabling harder cuts per unit metabolic energy.

Discussion

Golf balls intentionally trip turbulence to delay separation and reduce drag [9], whereas *Water Breathing* does the opposite, suppressing turbulence to minimise form drag. However, laminar flow at $Re \sim 10^6$ is unstable; adverse pressure gradients trigger breakdown in $\sim 10 \mu\text{s}$ [5].

Conclusion

Water Breathing, modelled as perfect laminar flow control, reduces aerodynamic torque by 94% and muscular effort by 45%, making the blade feel significantly lighter and enabling faster strikes. Whilst physically unrealisable due to rapid laminar breakdown ($\sim 10 \mu\text{s}$), this model provides a quantitative biomechanical basis for the fictional “effortless flow” effect in *Demon Slayer*.

References

- [1] https://kimetsu-noyaiba.fandom.com/wiki/Breathing_Style [Accessed 04 Nov. 2025].
- [2] https://www.thearma.org/spotlight/GTA/motions_and_impacts3.htm [Accessed 04 Nov. 2025].
- [3] https://www.researchgate.net/publication/309391411_Dynamic_Simulation_of_Japanese_Swords_During_Performing_Parrying_in_Kendo_Kata
Konyukhov, Alexander & Yeniavci, Halil. (2016). Dynamic Simulation of Japanese Swords During Performing Parrying in Kendo Kata.
- [4] https://www.engineersedge.com/physics/viscosity_of_air_dynamic_and_kinematic_14483.htm [Accessed 04 Nov. 2025].
- [5] <https://www.swordsofnorthshire.com/blogs/theblade/katana-length#:~:text=The%20katana%20is%20the%20longest,various%20purposes%20and%20combat%20scenarios.>
- [6] S. F. Hoerner, *Fluid-Dynamic Drag* (Hoerner Fluid Dynamics, 1965).
- [7] H. Schlichting and K. Gersten, *Boundary-Layer Theory*, 9th ed. (Springer, 2000).
- [8] <https://www.fst.com/news-stories/renewable-energies/human-power-plant/>
- [9] J. D. Anderson, *Fundamentals of Aerodynamics*, 6th ed. (McGraw-Hill, 2016).