Slug flow spreadsheet v1.3 'slug-flow-quadratics-verification.ods'#\$quadratics\_1 Single tunnel of constant area with losses, friction, jet fans, traffic drag and

portal pressures. Example that uses Darcy friction factor, positive airflow and traffic slower than air.

Tunnel	geometry	input	Tı	raffic in	put
Length	2000	•	Traffic speed (+ve)	u	10 km/h
Area	50	m²	Car flowrate	5	00 cars/hr
Perimeter	32	m	LCV flowrate		50 LCVs/hr
Friction type	Darcy	(Darcy/Fanning)	<b>HGV flowrate</b>	1	.00 HGVs/hr
Darcy fricfac λ	0.036	_	Car area		2 m <sup>2</sup>
Left portal loss	0.5	_	Car drag factor	(	0.4 —
Right portal loss	1	_	LCV area		4 m <sup>2</sup>
D_h (info only, not used)	6.25	m	LCV drag factor	(	<b>0.8</b> —
			HGV area		6 m²
V	Vind input		HGV drag factor	(	0.9 —
P at left portal	0	Pa Use blocka	age correction in calc?	N	(Y/N)
P at right portal	20	Pa			

Count of fans	10 —	Calculation (venicles slower than air
Static thrust	730 N at 1.2 kg/m <sup>3</sup>	Air velocity 3.152227 m/s
Jet velocity	30 m/s	Volume flow 157.611 m <sup>3</sup> /s
Installation efficiency	0.75 —	

Independent check calc of pressures		
Wind pressure	20.00 Pa	
Friction pressure	77.62 Pa	
Traffic pressure	0.37 Pa	
Jet fan pressure	-97.99 Pa	
Is the sum zero?	TRUE	

Slug flow spreadsheet v1.3 'slug-flow-quadratics-verification.ods'#\$quadratics\_2

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.

Example that uses Darcy friction factor, positive airflow and traffic faster than air.

Tunnel	geometry input		Tra	affic inp	out
Length	2000 m		Traffic speed (+ve)	:	<mark>10</mark> km/h
Area	50 m <sup>2</sup>		Car flowrate	50	00 cars/hr
Perimeter	<b>32</b> m		LCV flowrate	!	50 LCVs/hr
Friction type	Darcy (Darc	y/Fanning)	<b>HGV</b> flowrate	10	00 HGVs/hr
Darcy fricfac λ	0.036 —		Car area		2 m <sup>2</sup>
Left portal loss	0.5 —		Car drag factor	0	.4 —
Right portal loss	1 —		LCV area		4 m²
D_h (info only, not used)	6.25 m		LCV drag factor	0	<u> </u>
			HGV area		6 m²
V	Vind input		HGV drag factor	0	.9 —
P at left portal	<mark>0</mark> Pa	Use block	age correction in calc?	N	(Y/N)
P at right portal	<b>20</b> Pa				

Count of fans	2 —	Calculation (vehicle	s faster than air)
Static thrust	730 N at 1.2 kg/m <sup>3</sup>	Air velocity	1.065254 m/s
Jet velocity	30 m/s	Volume flow	53.263 m³/s
Installation efficiency	0.75 —		

Independent check	calc of pressures
Wind pressure	20.00 Pa
Friction pressure	8.86 Pa
Traffic pressure	-7.74 Pa
Jet fan pressure	-21.12 Pa
Is the sum zero?	TRUE

Slug flow spreadsheet v1.3

'slug-flow-quadratics-verification.ods'#\$quadratics 3

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.

Example that uses Darcy friction factor and negative airflow.

Tunnel geometry input		Т	Traffic input		
Length	200	<mark>0</mark> m	Traffic speed (+ve)		10 km/h
Area	5	0 m²	Car flowrate		500 cars/hr
Perimeter	3	<mark>2</mark> m	LCV flowrate		50 LCVs/hr
Friction type	Darcy	(Darcy/Fann	ing) HGV flowrate		100 HGVs/hr
Darcy fricfac λ	0.03	6 —	Car area		2 m²
Left portal loss	0.	5 —	Car drag factor		0.4 —
Right portal loss		1 —	LCV area		4 m <sup>2</sup>
D_h (info only, not used)	6.2	5 m	LCV drag factor		0.8 —
			HGV area		6 m²
V	Vind inpu	ıt	HGV drag factor		0.9 —
P at left portal		O Pa Use	blockage correction in calc?	N	(Y/N)
P at right portal	10	<mark>0</mark> Pa			

## Jet fan input

Count of fans	2 —	Calculation (revers	e airflow)
Static thrust	730 N at 1.2 kg/m³	Air velocity	-1.726343
Jet velocity	30 m/s	Volume flow	-86.317

Installation efficiency 0.75 -

### Air velocity -1.726343 m/s Volume flow -86.317 m<sup>3</sup>/s

Independent check calc of pressures		
Wind pressure	100.00 Pa	
Friction pressure	-23.28 Pa	
Traffic pressure	-53.56 Pa	
Jet fan pressure	-23.16 Pa	
Is the sum zero?	TRUE	

Slug flow spreadsheet v1.3 'slug-flow-quadratics-verification.ods'#\$quadratics\_4

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.

Example that uses Fanning friction factor, positive airflow and traffic slower than air.

Tunnel geometry input			Traffic input		
Length	2000	) m	Traffic speed (+ve)		<mark>10</mark> km/h
Area	50	m²	Car flowrate	5	00 cars/hr
Perimeter	32	2 m	LCV flowrate		50 LCVs/hr
Friction type	Fanning	(Darcy/Fanning)	<b>HGV</b> flowrate	10	00 HGVs/hr
Fanning fricfac c_f	0.009	) <u> </u>	Car area		2 m <sup>2</sup>
Left portal loss	0.5	<u> </u>	Car drag factor	C	).4 —
Right portal loss	1	l —	LCV area		4 m <sup>2</sup>
D_h (info only, not used)	6.25	j m	LCV drag factor	C	).8 —
			HGV area		6 m <sup>2</sup>
•	Wind inpu	t	HGV drag factor	C	).9 —
P at left portal	C	Pa Use bloc	kage correction in calc?	N	(Y/N)
P at right portal	20	) Pa			

Count of fans	10 —	Calculation (vehicles slower than air)
Static thrust	730 N at 1.2 kg/m <sup>3</sup>	Air velocity 3.152227 m/s
Jet velocity	30 m/s	Volume flow 157.611 m <sup>3</sup> /s
Installation efficiency	0.75 —	

Independent check	calc of pressures
Wind pressure	20.00 Pa
Friction pressure	77.62 Pa
Traffic pressure	0.37 Pa
Jet fan pressure	-97.99 Pa
Is the sum zero?	TRUE

Slug flow spreadsheet v1.3 'slug-flow-quadratics-verification.ods'#\$quadratics\_5

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.

Example with the traffic blockage correction term turned off.

**Traffic input Tunnel geometry input** 2000 m Traffic speed (+ve) 50 km/h Length 50 m<sup>2</sup> Car flowrate 1800 cars/hr Area 200 LCVs/hr 32 m LCV flowrate Perimeter Darcy (Darcy/Fanning) **HGV** flowrate 500 HGVs/hr Friction type 0.036 -Darcy fricfac λ Car area 2 m<sup>2</sup>0.5 -Left portal loss Car drag factor 0.4 -Right portal loss 1 — LCV area  $4 \, \mathrm{m}^2$ 6.25 m -8.0D h (info only, not used) LCV drag factor  $6 \, \mathrm{m}^2$ HGV area Wind input 0.9 -**HGV** drag factor 20 Pa Ν (Y/N) P at left portal Use blockage correction in calc? P at right portal 0 Pa

701	ian input		
Count of fans	4 —	Calculation (vehicle	es faster than air)
Static thrust	730 N at 1.2 kg/m <sup>3</sup>	Air velocity	5.347430 m/s
Jet velocity	30 m/s	Volume flow	267.371 m <sup>3</sup> /s
Installation efficiency	0.75 —		

Independent check calc of pressures					
Wind pressure	-20.00 Pa				
Friction pressure	223.38 Pa				
Traffic pressure	-167.39 Pa				
Jet fan pressure	-35.99 Pa				
Is the sum zero?	TRUE				

Slug flow spreadsheet v1.3 'slug-flow-quadratics-verification.ods'#\$quadratics\_6

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.

Example with the traffic blockage correction term turned on and the drag factors adjusted to cancel out the correction.

Tunnel geometry input				Traffic input		
Length	2000 m		7	Traffic speed (+ve)		50 km/h
Area	5	0 m²	(	Car flowrate	180	00 cars/hr
Perimeter	3:	<mark>2</mark> m	L	_CV flowrate	20	00 LCVs/hr
Friction type	Darcy	(Darcy/Fann	ning) I	HGV flowrate	50	00 HGVs/hr
Darcy fricfac λ	0.03	6 —	(	Car area		$2 \text{ m}^2$
Left portal loss	0.	5 —	(	Car drag factor	0.368	64 —
Right portal loss		1 —	L	_CV area		4 m <sup>2</sup>
D_h (info only, not used)	6.2	5 m	L	_CV drag factor	0.677	12 —
			H	HGV area		6 m²
V	Vind inpu	ıt	H	HGV drag factor	0.696	96 —
P at left portal	20	<mark>0</mark> Pa Use	blockage	e correction in calc?	Υ	(Y/N)
P at right portal	(	<mark>0</mark> Pa				

Count of fans	4 —	Calculation (vehicles faster than air		
Static thrust	730 N at 1.2 kg/m³	Air velocity 5.347430 m/s		
Jet velocity	30 m/s	Volume flow 267.371 m <sup>3</sup> /s		
Installation efficiency	0.75 —			

Independent check calc of pressures					
Wind pressure	-20.00 Pa				
Friction pressure	223.38 Pa				
Traffic pressure	-167.39 Pa				
Jet fan pressure	-35.99 Pa				
Is the sum zero?	TRUE				

Slug flow spreadsheet v1.3 'slug-flow-quadratics-verification.ods'#\$quadratics\_7

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.

Example with the traffic flow and drag data switched around.

Tunnel geometry input				Traffic input		
Length	2000 m		Traffic speed	(+ve)	50 km/h	
Area	5	<mark>0</mark> m²	Car flowrate		500 cars/hr	
Perimeter	3	<mark>2</mark> m	LCV flowrate		1800 LCVs	/hr
Friction type	Darcy	(Darcy/Fanr	ing) HGV flowrate		200 HGV:	s/hr
Darcy fricfac λ	0.03	6 —	Car area		6 m²	
Left portal loss	0.	5 —	Car drag facto	or	0.9 —	
Right portal loss		1 —	LCV area		2 m²	
D_h (info only, not used)	6.2	5 m	LCV drag facto	or	0.4 —	
			HGV area		4 m²	
V	Vind inpu	ıt	HGV drag fact	tor	0.8 —	
P at left portal	2	<mark>0</mark> Pa Use	blockage correction in	n calc?	(Y/N	)
P at right portal		<mark>0</mark> Pa				
Je	et fan inp	ut				

Count of fans	4 —	Calculation (vehicles faster than ai		
Static thrust	730 N at 1.2 kg/m <sup>3</sup>	Air velocity	5.347430 m/s	
Jet velocity	30 m/s	Volume flow	267.371 m <sup>3</sup> /s	
Installation efficiency	0.75 —			

Independent check calc of pressures					
Wind pressure	-20.00 Pa				
Friction pressure	223.38 Pa				
Traffic pressure	-167.39 Pa				
Jet fan pressure	-35.99 Pa				
Is the sum zero?	TRUE				

Slug flow spreadsheet v1.3

'slug-flow-quadratics-verification.ods'#\$quadratics\_8

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.

Example with the traffic flow and drag data switched again and the pressures modified

Tunnel	Traffic input				
Length	200	0 m	Traffic speed (+ve)		50 km/h
Area	5	<mark>0</mark> m²	Car flowrate	2	00 cars/hr
Perimeter	3	<mark>2</mark> m	LCV flowrate	5	00 LCVs/hr
Friction type	Darcy	(Darcy/Fanning)	HGV flowrate	18	00 HGVs/hr
Darcy fricfac λ	0.03	6 —	Car area		4 m <sup>2</sup>
Left portal loss	0.5 —		Car drag factor	0.8 —	
Right portal loss		1 —	LCV area		6 m <sup>2</sup>
D_h (info only, not used)	6.25 m		LCV drag factor	0.9 —	
			HGV area		2 m <sup>2</sup>
V	Vind inpu	ıt	HGV drag factor	(	).4 —
P at left portal		OPa Use block	cage correction in calc?	N	(Y/N)
P at right portal	-2	0 Pa			

## Jet fan input

Installation efficiency

Count of fans	4 —	Calculation (vehicle	s faster than air)
Static thrust	730 N at 1.2 kg/m³	Air velocity	5.347430 m/s
Jet velocity	30 m/s	Volume flow	267.371 m <sup>3</sup> /s

0.75 -

### 

Is the sum zero?

independent check	caic of pressures
Wind pressure	-20.00 Pa
Friction pressure	223.38 Pa
Traffic pressure	-167.39 Pa
Jet fan pressure	-35.99 Pa

**TRUE** 

Slug flow spreadsheet v1.3

'slug-flow-quadratics-verification.ods'#\$quadratics\_9

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.

Example with the traffic just slower than the airflow

Tunnel geometry input			Ti	Traffic input		
Length	2000 m		Traffic speed (+ve)		18 km/h	
Area	5	0 m²	Car flowrate	18	1800 cars/hr	
Perimeter	3	<mark>2</mark> m	LCV flowrate	2	200 LCVs/hr	
Friction type	Darcy	(Darcy/Fann	ing) HGV flowrate	5	00 HGVs/hr	
Darcy fricfac λ	0.03	6 —	Car area		2 m²	
Left portal loss	0.	5 —	Car drag factor	(	0.4 —	
Right portal loss		1 —	LCV area		4 m²	
D_h (info only, not used)	6.2	5 m	LCV drag factor	(	0.8 —	
			HGV area		6 m <sup>2</sup>	
V	Vind inpu	ıt	HGV drag factor		0.9 —	
P at left portal	94.9	2 Pa Use	blockage correction in calc?	N	(Y/N)	
P at right portal		0 Pa				
Je	et fan inp	ut				

	-	
Count of fans	11 —	Calculation (vehicles faster than air)
Static thrust	730 N at 1.2 kg/m³	Air velocity 4.999939 m/s
Jet velocity	30 m/s	Volume flow 249.997 m <sup>3</sup> /s
Installation efficiency	0.75 —	

Independent check calc of pressures					
Wind pressure	-94.92 Pa				
Friction pressure	195.30 Pa				
Traffic pressure	0.00 Pa				
Jet fan pressure	-100.38 Pa				
Is the sum zero?	TRUE				

Slug flow spreadsheet v1.3

'slug-flow-quadratics-verification.ods'#\$quadratics\_10

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.

Example with the traffic just faster than the airflow

Tunnel geometry input			T	Traffic input		
Length	2000	<mark>)</mark> m	Traffic speed (+ve)		18 km/h	
Area	50	<mark>0</mark> m²	Car flowrate	1	L <mark>800</mark> cars/hr	
Perimeter	3:	<mark>2</mark> m	LCV flowrate		200 LCVs/hr	
Friction type	Darcy	(Darcy/Fann	ing) HGV flowrate		500 HGVs/hr	
Darcy fricfac λ	0.03	6 —	Car area		2 m²	
Left portal loss	0.	5 —	Car drag factor		0.4 —	
Right portal loss		1 —	LCV area		4 m <sup>2</sup>	
D_h (info only, not used)	6.2	5 m	LCV drag factor		0.8 —	
			HGV area		6 m <sup>2</sup>	
V	Vind inpu	t	HGV drag factor		0.9 —	
P at left portal	94.9	3 Pa Use	blockage correction in calc?	N	(Y/N)	
P at right portal	(	O Pa				
Je	t fan inp	ut				

Count of fans	11 —	Calculation (vehicles slower than air)
Static thrust	730 N at 1.2 kg/m <sup>3</sup>	Air velocity 5.000061 m/s
Jet velocity	30 m/s	Volume flow 250.003 m <sup>3</sup> /s
Installation efficiency	0.75 —	

Independent check calc of pressures					
Wind pressure	-94.93 Pa				
Friction pressure	195.30 Pa				
Traffic pressure	0.00 Pa				
Jet fan pressure	-100.37 Pa				
Is the sum zero?	TRUE				

Slug flow spreadsheet v1.3

'slug-flow-quadratics-verification.ods'#\$quadratics\_11

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.

Example with the air velocity positive and just above zero.

Tunnel geometry input			Traffic input			
Length	200	<mark>0</mark> m		Traffic speed (+ve)		18 km/h
Area	5	$0 \text{ m}^2$		Car flowrate	2	00 cars/hr
Perimeter	3	<mark>2</mark> m		LCV flowrate	5	00 LCVs/hr
Friction type	Darcy	(Darcy/Fa	anning)	HGV flowrate	18	00 HGVs/hr
Darcy fricfac λ	0.03	6 —		Car area		$4 \text{ m}^2$
Left portal loss	0.	5 —		Car drag factor	(	).8 —
Right portal loss		1 —		LCV area		6 m <sup>2</sup>
D_h (info only, not used)	6.2	5 m		LCV drag factor	(	).9 —
				HGV area		$2 \text{ m}^2$
V	Vind inpu	ıt		HGV drag factor	(	0.4 —
P at left portal	(	<mark>0</mark> Pa	Use blocka	ge correction in calc?	N	(Y/N)
P at right portal	192.1	8 Pa				
Je	et fan inp	ut				

Count of fans	3 —	Calculation (vehicles faster than air			
Static thrust	730 N at 1.2 kg/m <sup>3</sup>	Air velocity	0.000051 m/s		
Jet velocity	30 m/s	Volume flow	0.003 m <sup>3</sup> /s		
Installation efficiency	0.75 —				

Independent check calc of pressures					
Wind pressure	192.18 Pa				
Friction pressure	0.00 Pa				
Traffic pressure	-159.33 Pa				
Jet fan pressure	-32.85 Pa				
Is the sum zero?	TRUE				

Slug flow spreadsheet v1.3

'slug-flow-quadratics-verification.ods'#\$quadratics\_12

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.

Example with the air velocity negative and just below zero.

Tunnel geometry input			Traffic input			
Length	200	<mark>0</mark> m		Traffic speed (+ve)		18 km/h
Area	5	0 m²		Car flowrate	18	300 cars/hr
Perimeter	3:	<mark>2</mark> m		LCV flowrate	2	200 LCVs/hr
Friction type	Darcy	(Darcy/Fa	nning)	HGV flowrate		00 HGVs/hr
Darcy fricfac λ	0.03	6 —		Car area		2 m <sup>2</sup>
Left portal loss	0.	5 —		Car drag factor		0.4 —
Right portal loss		1 —		LCV area		4 m²
D_h (info only, not used)	6.2	5 m		LCV drag factor		<b>0.8</b> —
				HGV area		6 m²
V	Vind inpu	ıt		HGV drag factor		0.9 —
P at left portal	(	<mark>0</mark> Pa	Jse blocka	ge correction in calc?	N	(Y/N)
P at right portal	192.1	9 Pa				
Je	et fan inp	ut				

### 3 —

Count of fans	3 —	Calculation (reverse airflo		
Static thrust	730 N at 1.2 kg/m³	Air velocity	-0.000103	
Jet velocity	30 m/s	Volume flow	-0.005	

0.75 -

Air velocity -0.000103 m/s

 $-0.005 \,\mathrm{m}^3/\mathrm{s}$ 

ndependent check calc of pressures					
Wind pressure	192.19 Pa				
Friction pressure	0.00 Pa				
Traffic pressure	-159.34 Pa				
Jet fan pressure	-32.85 Pa				
Is the sum zero?	TRUE				

Installation efficiency

Slug flow spreadsheet v1.3

Count of fans

'slug-flow-quadratics-verification.ods'#\$quadratics\_13

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.

Example in which the jet fan thrust exactly balances the wind pressure difference.

Tunnel geometry input			Т	Traffic input		
Length	200	<mark>0</mark> m	Traffic speed (+ve)		50 km/h	
Area	5	0 m²	Car flowrate		0 cars/hr	
Perimeter	3	<mark>2</mark> m	LCV flowrate		O LCVs/hr	
Friction type	Darcy	(Darcy/Fann	ning) HGV flowrate		O HGVs/hr	
Darcy fricfac λ	0.03	6 —	Car area		2 m²	
Left portal loss	0.	5 —	Car drag factor		0.4 —	
Right portal loss		1 —	LCV area		4 m²	
D_h (info only, not used)	6.2	5 m	LCV drag factor		0.8 —	
			HGV area		6 m <sup>2</sup>	
V	Vind inpu	ıt	HGV drag factor		0.9 —	
P at left portal		<mark>0</mark> Pa Use	blockage correction in calc?	N	(Y/N)	
P at right portal	43.	8 Pa				
Je	et fan inp	ut				

### 4 —

Count of fails	•
Static thrust	730 N at 1.2 kg/m³
Jet velocity	30 m/s

Installation efficiency 0.75 —

Air velocity 0.000000 m/s

Volume flow 0.000 m³/s

Calculation (vehicles faster than air)

### ndependent check calc of pre

Is the sum zero?

Independent check calc of pressures			
Wind pressure	43.80 Pa		
Friction pressure	0.00 Pa		
Traffic pressure	0.00 Pa		
Jet fan pressure	-43.80 Pa		

**TRUE** 

Slug flow spreadsheet v1.3

'slug-flow-quadratics-verification.ods'#\$quadratics\_14

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.

Example in which the traffic drag exactly balances the jet fan thrust.

This case also verifies that jet fans blowing backwards are handled correctly.

Tunnel geometry input		Т	Traffic input			
Length	2000 m		Traffic speed (+ve)		36 km/h	
Area	50 m²		Car flowrate	821.	25 cars/hr	
Perimeter	32 m		LCV flowrate	0 LCVs/hr		
Friction type	Darcy	(Darcy/Fanni	ng) HGV flowrate		O HGVs/hr	
Darcy fricfac λ	0.036 —		Car area		2 m²	
Left portal loss	0.5 —		Car drag factor	(	0.4 —	
Right portal loss	1 —		LCV area		4 m²	
D_h (info only, not used)	6.25 m		LCV drag factor	0.8 —		
			HGV area		6 m <sup>2</sup>	
Wind input		HGV drag factor	0.9 —			
P at left portal		O Pa Use	blockage correction in calc?	N	(Y/N)	
P at right portal		0 Pa				

Count of fans	4 —	Calculation (vehicle	es faster than air)
Static thrust	730 N at 1.2 kg/m <sup>3</sup>	Air velocity	0.000000 m/s
Jet velocity	-30 m/s	Volume flow	0.000 m <sup>3</sup> /s
Installation efficiency	0.75 —		

Independent check calc of pressures				
Wind pressure	0.00 Pa			
Friction pressure	0.00 Pa			
Traffic pressure	-43.80 Pa			
Jet fan pressure	43.80 Pa			
Is the sum zero?	TRUE			