# Gas Forges – Theory & Practice

Wisdom is learning from *other* people's experience/mistakes

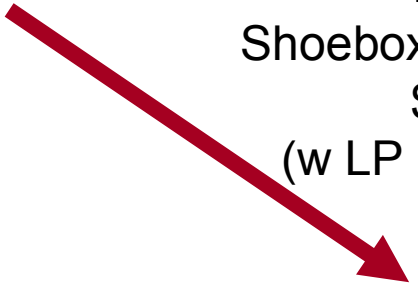
## Fuel

| Coal | Gas |
|---|---|
| Spot Heating | Uniform Heating |
| Versatility | Production |
| Authenticity | Convenience |
| Neighbor Acceptability | |
| Problematic | Blissful Ignorance |
| Fuel Access | |
| Poor | Good |

## Burner

Commercial forges
1.. 2 burners
Shoebox to 5 1/2" x 9" x 16"
$420 to $900+
(w/o LP parts)

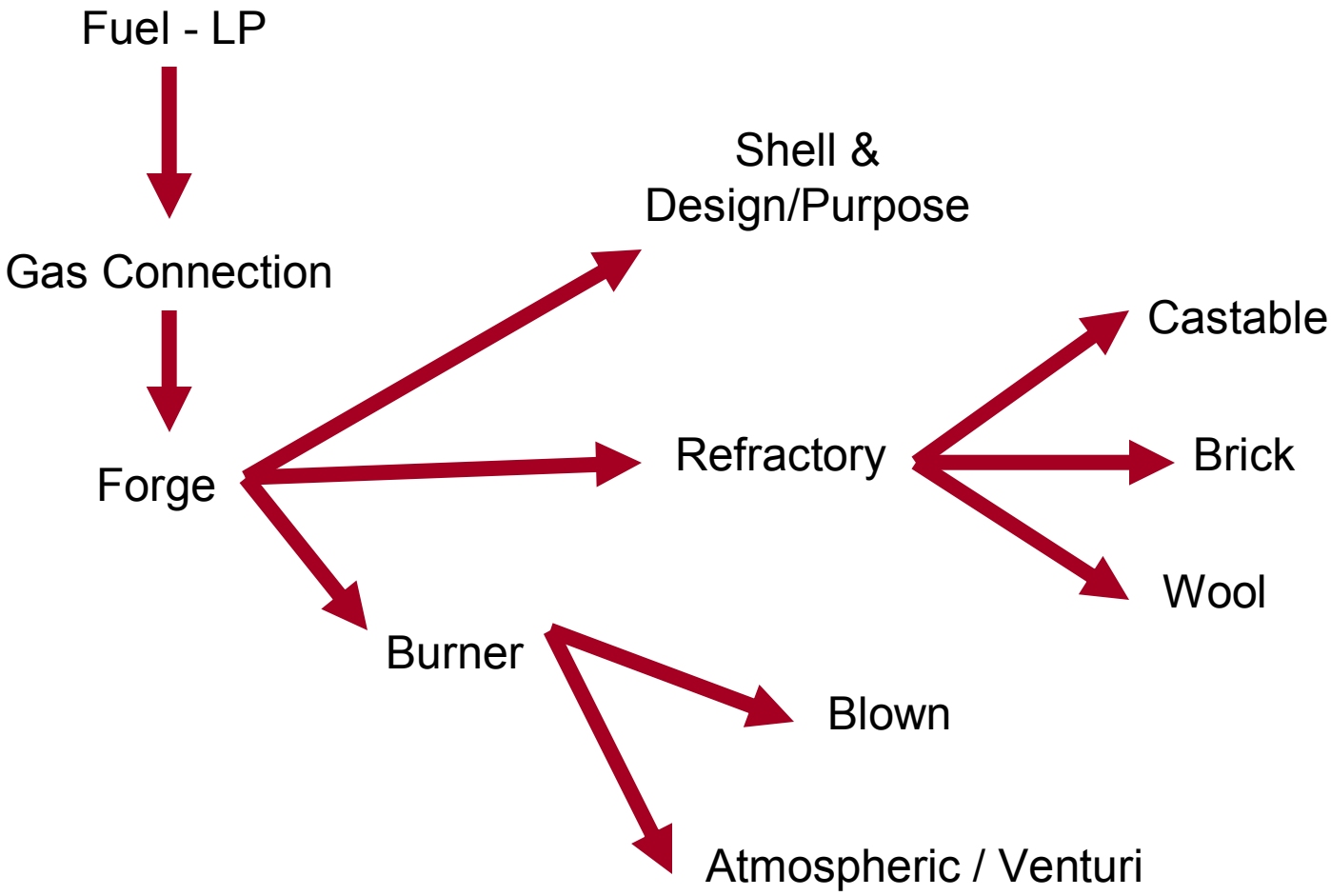
Homemade forges
1.. 2 burners
Shoebox to 5 1/2" x 9" x 16"
$50 to $100
(w LP parts – add $100)



## Box

# Gas Forges – Theory & Practice

## Basic Components



## LP Characteristics

| | |
|---|---|
| Composition | $C_3H_8$ |
| Boiling Point | -44°F |
| Flammability Limits | 2.15 - 9.60% |
| Ignition Temperature in Air | 920-1020°F |
| Maximum Flame Temperature | 3595°F |

## LP Implications

Composition - manufactured hydrocarbon from oil or natural gas.

**Too Little** **Oxygen level** **Too much**

CO - carbon monoxide ← $CO_2$ – carbon dioxide →

Excessive scaling

Denser than air - BBQ tank (20 lbs) = 4.1 gal or ~16 lbs LP
~6900 $ft^3$ of combustible mix =30’ x 30’ x 8’ space
x ~0.51 lb TNT/lb LP = 8.6 lb TNT = 16 sticks ‘nuf said?

Auto Ignition @ ~1000°F (reason for “flame holders”)

Max Temperature more than adequate for smithing

## LP Implications (continued)

Can be used as a liquid or a gas – both NOT both
Virtually all non-industrial uses are with gas

Tanks hold propane as a liquid due to pressure (100-200 psi)

As gas is used, tank cools until ice form on the exterior.
The colder the tank, the less the gas flow –

Solution is a water bath (slack tub, tote, etc.) BUT bungee cord the tank upright = it will float. You DO NOT want liquid propane to make you day real exciting.

# LP Connections & Hardware

Tank – old style CAN be filled –
mark “Cutting/Welding Only”

POL connects tank to regulator
Regulator ought to be 0 to 30 psi
Gauge is nice (not required)
LP hose is a GOOD idea

Assembly available for < $60.00*
http://www.hightemptools.com/propaneregulators.html

Recommended: a shutoff valve & male & female quick disconnect fittings.
< $30 and add $3.50 for additional male fittings (one per unit)

**Bottom Line: Expect $100 to start but the gear can move from unit to unit**

## Forge Components - Refractory

Refractory is any material designed to resist decomposition under repeated exposure to high temperatures

Trade-off is between costs, temperature ranges, insulation levels, ease of working, possible health implications and the demands placed on the forge

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**Mizzou Castable Refractory:**

3000 degree F, High Alumina Castable with a very high resistance to flux, relative low insulation ability, significant weight, low cost (55 lb bag - $65)

**Refractory Bricks:**

3000 F soft brick: 9 x 4.5 x 2.5 K-30 IFB, easily shaped, intermediate weight and insulation ability, ~$6..$10/brick (K24=2400$^{O}$F –so check!)

**Wools (InsWool…Kaolwool):**

2400 F blanket (1 to 2” thick), minimum weight, maximum insulation ability, $16.50 per 2 sq. ft, potential health problems – must be stabilized

**Satanite Refractory Mortar:**

Refractory mortar works great for sealing the Inswool/Kaowool fibers on the walls of your forge. 3200 degree temperature rating; 55 pound bag - $88.00

## Forge Components - Refractory

Assume a 9” x 9” x 9” forge with 2 to 2.5” thick walls (single burner)

| Comparison (2400 F unit): | | Cost | Lbs | ratio |
|---|---|---|---|---|
| Castable: | ~60% of a bag (0.3 $ft^3$) | $39 | 45.1 | 14 |
| Bricks: | 6 @ K24 or K30 | $36 .. $60 | 12.9 | 4 |
| Wool: | ~4 $ft^2$ x 2” | $34 | 3.2 | 1 |

(low to high)

Weight : wool – brick - castable
Time to reach operating temperature : wool – brick – castable
Heat capacity (resistance to cooling on next piece) : castable – brick – wool
Time to cool to ambient (room) temperature : wool – brick – castable

Handle with care & use masks when fabricating – for all refractories

Wool is implicated in some studies as a cancer-causing agent – no human data as yet, definite hit on ingestion in hamsters & rats, suggestions of hit on lungs in non-human subjects at industrial exposures – stabilization & immediate repairs on surface defects are strongly recommended.

## Forge Components - Refractory

Forge Weight : 8” pipe (1/4” wall) = 16 lbs, sheet steel (16 gauge) = 7 lbs

Usual patterns:

People doing massive blocks of Damascus (10-20 lb billets) with multiple blocks per day like castable forges

People doing knife work (little chance of damaging the sides of the unit) or doing demonstrations where weight and cool down speed are important like wool.

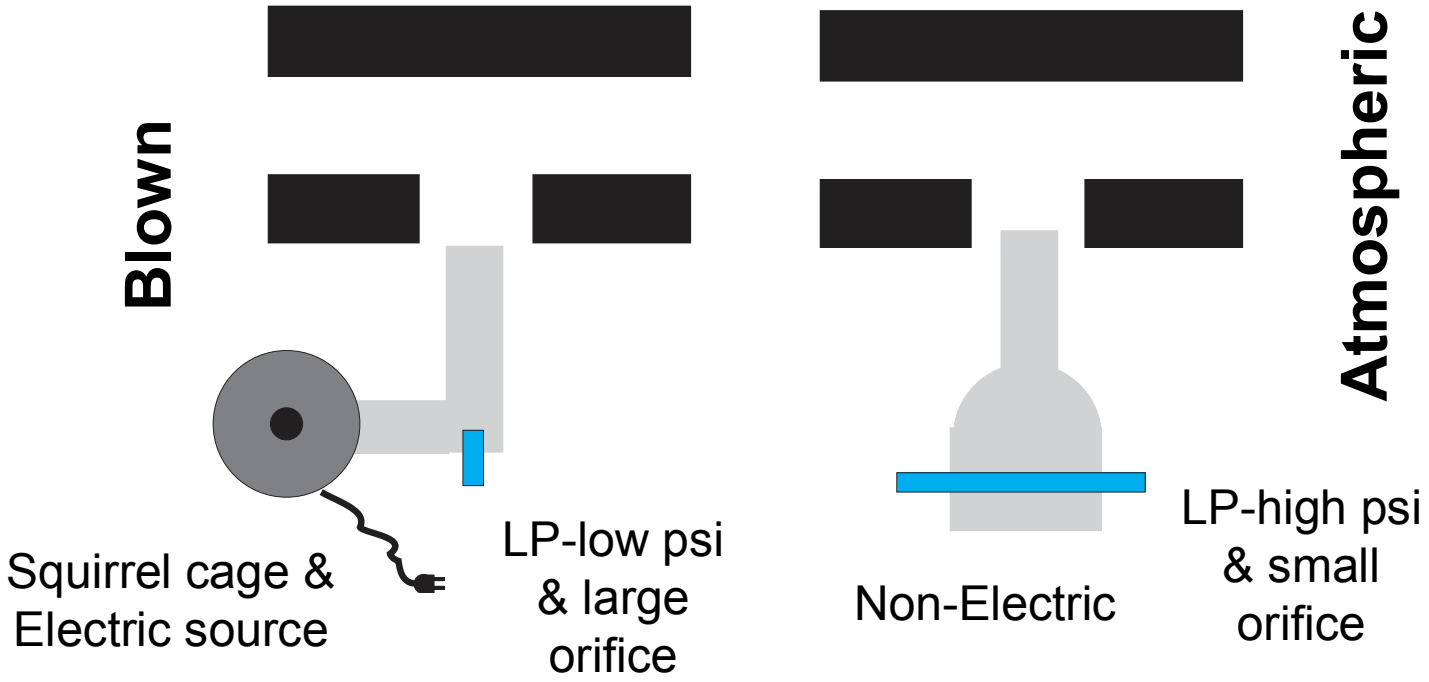
Bricks tends to be used for shop forges, for products of uncertain sizes & shapes and as a balance between the various characteristics

HINT: Look for used pottery kilns – cheap source of brick!

**Pays your money, take your chances!**

## Forge Components -Burners

Disclaimer : Ford vs Chevy – Expert advice of questionable practical utility




Both require fuel & air in 2..9% ratio, ignition point ~1000$^{O}$F &
Sufficient air flow to get the flame into the forge

## Forge Components -Burners

Concepts: Auto ignition – At forging temps, walls will suffice, so….

Blown units are dependent on electrical supply – w/o fan, flame front will back down feed pipe – may blow out fan or just gutter out (> 9%) and then leak gas until – BANG?—

Atmospherics w/o sufficient gas pressure will “gutter” – flame front backs up narrow section – audio signal long before problems

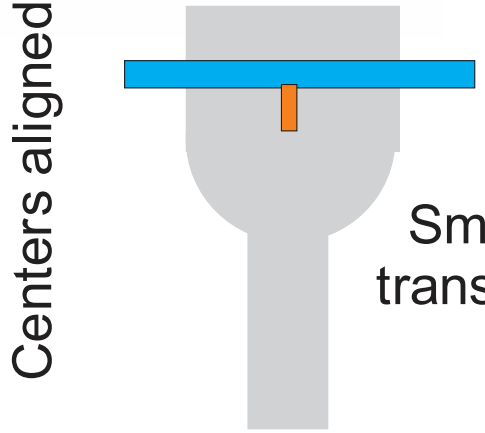
**Myths**:
Atmospherics cannot support reducing atmosphere,
Hard to ‘tune’,
Require ultra-precise fabrication,
Require exotic parts,
Consume excessive amounts of fuel

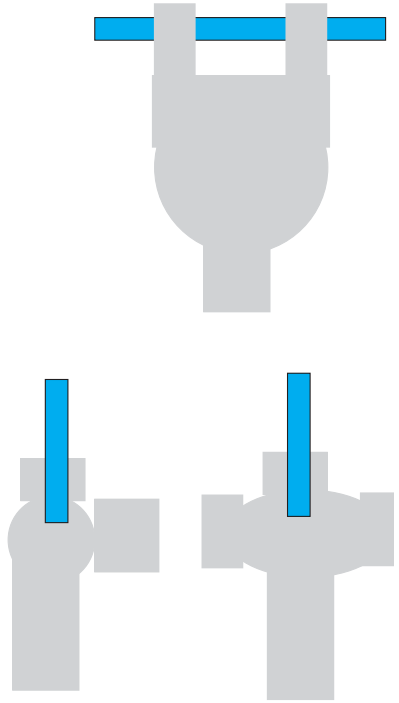
**Bottom Line** – Both work & both are not difficult to create

## Forge Components –Atmospheric Burners

Concepts: orifice must be down the bore – either adjustable or locked-in
Costs in black iron & galvanized fittings  apprx $10

Large section (2..3” diameter*)



Narrow section (~1” diameter**)

*  1.5 to 2.5” pipe
**  3/4” pipe
*** 1/4” pipe

## Forge Components –Atmospheric Burners

How it works – jet of gas into center of narrow pipe sucks air into large bell – when flow narrows, pressure increases – air & gas jet into the forge.

Laminar vs turbulent flow – the less resistance to flow, the more efficient
implications – there are lower limits to pipe size for a given gas pressure

If design has alignment built in (T-rex, side-arm, etc.), lathe is needed

If design allows adjusting gas jet to align with center, less precision needed ---such as a drill press and a decent “eye”

Tune by rotation of gas pipe (CW or CCW) and moving orifice back & forth until maximum sounds occurs – make sure jet is initially down into the burner and use the forge or a forge stand-in to maintain burn

## Forge Components –Shell

Need to stabilize refractory & burners – so wrap refractory in a shell

Pipe – needlessly heavy (but if available…..)
Black iron (16 gauge?) – will eventually rust out
Stainless – expensive and difficult to work

Relationship of burner number, internal volume of forge, maximum heat, whether there will be auxiliary air flow, purpose of forge – all play a role

Rough guide – 2 burners with 0.040 orifices at 15 psi into :

550-600 $in^3$ (half of a 9” circle x 18” of length) < $2400^{O}F$ (welding heat)
with forced air (tiny squirrel cage) – welding possible

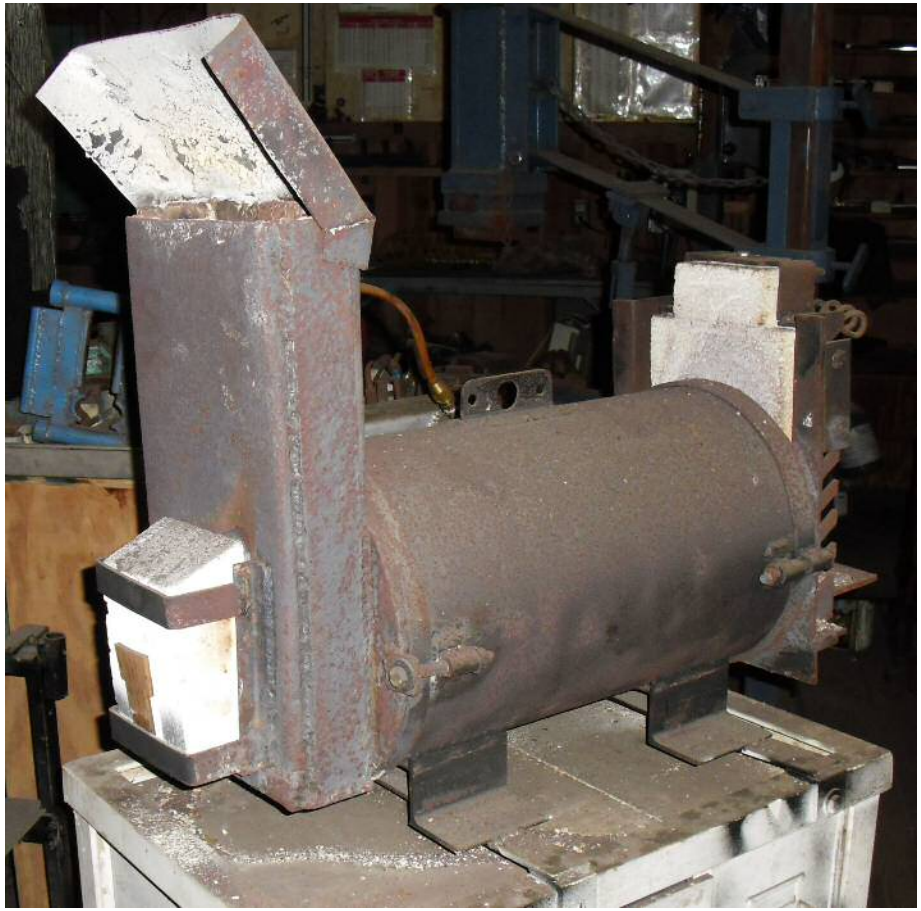
~300 $in^3$ (half of a 6” circle x 18” of length) with fan > $3000^{O}F$

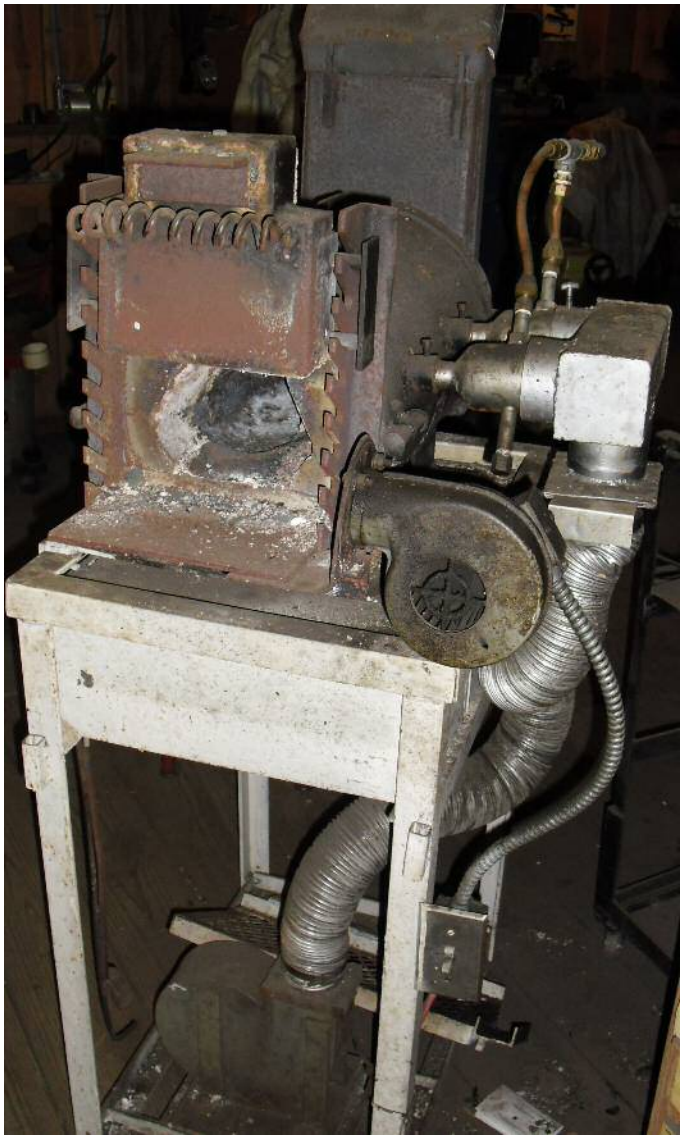
# Forge Components –Shell Examples

General Purpose forges

# Forge Components –Shell Examples

Damascus forges





# Forge Components –Shell Examples

Heat Treating - Salt

Heat Treating - Fogg

# Forge Components –Shell Examples

Knife Forging

Casting