ISSF
INTERNATIONAL STAINLESS STEEL FORUM

Clean Cooking with Stainless Steel

Cover picture courtesy of TERI, India

Disclaimer

Introduction

Chronic exposure to smoke from traditional cooking practices is one of the world's biggest – but least well-known – killers. According to the Global Alliance for Clean Cookstoves (www.cleancookstoves.org), nearly 3 billion people in the developing world cook their food and heat their homes with traditional stoves or open fires. The Global Burden of Disease Study 2010 estimates that exposure to smoke from the simple act of cooking is the fourth worst risk factor for disease in developing countries, and causes four million premature deaths per year – exceeding deaths attributable to malaria or tuberculosis.

Photo courtesy of Nigel Bruce, University of Liverpool

Health effects

Women and children are the most affected. Reliance on inefficient stoves and fuels leads to health problems, typically emphysema, cataracts, cancer and heart disease. Breathing smoke from open fires and traditional cooking stoves is also associated with low birth-weight in children born to mothers whose pregnancies are spent in a polluted domestic environment.

Rudimentary wood-fired cooking stoves and open fires emit particulate matter, carbon monoxide, and other pollutants at levels up to 100 times higher than the recommended limits set by WHO. Health effects are especially deadly for children under the age of five.

Apart from toxicity issues, women in developing countries are also at risk of head and spinal injuries, pregnancy complications and maternal mortality from the strenuous task of carrying heavy loads of firewood or other fuels. Burns from unsafe cooking stoves are another risk faced by poor households dependent on kerosene, open fires, and structurally unstable metal or clay cooking stoves.

Typical health risks: exposure to smoke and the collection of fire wood.
Source : Photo by Micael Benanav (left) and Global Alliance for Cleaner Cookstoves (USA), www.cleancookstoves.org (right)

Environmental effects

Inefficient rudimentary cooking techniques emit unnecessary amounts of CO_2. They also produce black carbon and methane, which are particularly strong contributors to global warming.

In many countries, charcoal is a usual cooking fuel. The unsustainable collection of wood for charcoal production has led to native forests being stripped. Landslides and desertification are among the catastrophic long-term consequences of this practice.

There are several types of advanced biomass stoves that can achieve high levels of performance. In many of them, stainless steels make a contribution to enhanced functionality, cost efficiency and aesthetics. Besides their proven corrosion resistance, also their physical properties can be important: austenitic grades have low thermal conductivity. Depending on the design, the outside does not get excessively hot. Easy forming and welding is important for low-cost production, and again stainless steel performs best among volume engineering materials. Ferritic and chromium-manganese alloys help to reduce material cost and make advanced cooking stoves affordable also for low-income families. The reflective properties open up new fields of application in solar cooking. The material stainless steel proves useful in the most diverse types of appliances.

Forced air stoves

Forced air stoves have a fan typically powered by batteries, an external source of electricity, or a thermoelectric device that captures heat from the stove and converts it to electricity. This fan blows high velocity, low volume jets of air into the combustion chamber. The extra oxygen optimises fuel combustion and ensures no unacceptable levels of carbon monoxide (CO) and black carbon are produced.

Forced air stove with electrically powered fans and rechargeable batteries for use with photovoltaic cells.
Source: TERI (India), www.rbsgroup.in

An Indian manufacturer recently developed a forced-air cooking stove, which enhances combustion efficiency substantially. For the body, stainless steel turned out to be an ideal material. Its intrinsic corrosion resistance makes the stove last longer than painted and galvanised models. In the case of stainless steel, there are no coatings that could age and fail under the effect of high temperatures or robust handling. The smooth surfaces are easy to clean.

The fabricator uses austenitic grades for his design. They have outstanding formability and are easy to weld. A material mix of chromium-nickel and chromium-nickel-manganese types also makes the device affordable.

The 50% lower fuel consumption, together with shorter cooking times, lead to a 70% reduction in

smoke compared to simple open stoves. The enhanced combustion also minimises particulate matter formation and the unsightly blackening of kitchen walls and cooking pots.

Gasifier stoves

Gasifier stoves force the gases and smoke that result from incomplete combustion back into the flame and ensure they are burnt as efficiently as possible.

A company from Lesotho provides stoves that are based on the gasification principle and burn almost any type of biomass with only minimal smoke emissions. A fan blows oxygen into the chamber through holes at both the bottom and the top. This drives the temperature within the flame up to approximately 1000 °C causing the biomass to gasify. The hot gas rises to the top, where it reacts with additional oxygen and burns efficiently.

The inside of the stove is clad with 20 mm refractory tiles. For the body, type 304 stainless steel is used. Due to the low thermal conductivity, the walls do not reach temperatures high enough to cause injury. The stove is an example of how corrosion resistance and decorative surfaces are not the only reasons to specify stainless steel; also the physical properties are used to provide the product-specific properties.

Type 304 stainless steel is used for the body. A fully charged battery will power the fan for over 20 hours of cooking. The battery can also be used to charge a mobile device or run LED lighting.

The device burns a wide variety of biomass, including collected wood like sticks and twigs, but also cow dung, and corn-cobs. It also burns processed biomass fuels like wood pellets and briquettes, which are made from waste materials

Gasifier stoves are not only used in non-electrified settlements, they are also used for leisure purposes to contribute to the outdoor experience.
Source: African Clean Energy (Lesotho), www.africancleanenergy.com

like sawdust, forestry waste, or agricultural waste. Charcoal is another option; however it is only recommended from an environmental point of view where sustainable charcoal production can be ensured.

Pellets made from waste wood.
Source: African Clean Energy / Andrew Writer

Some types of stoves are optimised for particular types of fuel. An example is an Indian product, which is designed specifically to burn rice husk. It is a batch-type, top-lift updraft (TLUD) gasifier stove.

The capacity of the pot is 4 to 8 litres. A 1 kg batch of rice husk suffices to ensure one hour of cooking operation. As in the previously mentioned types, it includes an electrical fan, re-chargeable batteries and solar cells for the system to work also in non-electrified regions. The use of agricultural waste is an excellent way of fostering sustainable sources of energy and fight deforestation.

Government programmes now ask manufacturers to test their appliances for particulate matter and CO_2 emissions and thermal energy output so consumers can compare alternative methods and models available in the market.

Rice Husk Gas Stove.
Source: Nav Durga Metals Industries (India), http://ndmi.co.in

Rocket cooking stoves

Rocket stoves include an L-shaped combustion chamber. Their design improves heat transfer by narrow channels, which direct the flow of hot gases closer to the pot.

L-shaped combustion chamber of a rocket stove, assembled (above) and as delivered in a flat pack.
Source: Rocket Works (RSA), www.rocketworks.org

Other fuels

Other fuels include alcohol (methanol in liquid or gel form), locally produced biogas, liquefied petroleum gas (LPG) and compressed natural gas (CNG), for which stainless steel-containing equipment is also available.

Ethanol cooking stove.
Source: Dometic (Sweden),www.dometic.com

Solar cooking stoves

Solar cooking stoves can be used in areas where solar energy is abundant for most of the year. According to NASA insolation maps, this technology is applicable between 30 degrees north and south of the equator, where much of the developing world is located. There are three types of solar cookers: panel, box and parabolic, all of which generate heat by directly capturing the sun's solar thermal energy.

Parabolic cookers resemble satellite dishes. They cook as fast as an open fire by focusing sunlight onto the bottom of a cooking pot. Parabolic solar cookers can be used from sunrise until sunset. As they use the thermal energy conveyed by radiation, not convection, they can generate temperatures of more than 230 °C (about 450 °F) even at sub-zero ambient air temperature.

A manufacturer in Sudan developed a parabolic dish style cooker 1.8 meters in diameter with a double axis manual tracking system, which incorporates a stainless steel reflector.

Bright annealed stainless steel is a cost-effective option for the mirror. It is a mill product that is produced in large quantities for instance for the domestic appliance industry. Economies of scale make it a cost-effective solution.

Stainless steel parabolic dish for solar cooking stove.
Source: Solar Energy Enterprises (Sudan), http://solarcooking.wiki.com

Panel cookers depend on the same physical principle, but, they involve foldable reflectors. Experience shows that they can produce temperatures of 120 °C to 180 °C (approximately 200 to 300 F). Basic models are common in developing countries; but the principle has also spread to industrialised countries, where the "hot pot" has become a lifestyle article.

Basic panel cooker involving a metal foil on a cardboard support.
Source: www.wikimedia.org

All-metal panel cooker.
Source: Inspiration Green Home (USA), www.inspirationgreen.com

In the case of box cookers, the lid is made of a mirror-like material. It reflects the solar radiation into a blackened box, into which the cooking pots are placed. Box cookers are bigger and less portable than panel cookers, however, larger models can hold several cooking pots. The temperature range is typically between 180 °C and 200 °C (about 350 to 400 F).

Solar box cookers.
Source: Solar Energy Enterprise Co. Ltd. (Sudan), http://solarcooking.wiki.com

In most variants of solar cooking devices, other materials still prevail; however, reflective stainless steel has great potential. Bright annealed surfaces are a volume mill product, which is made at an industrial scale mainly for the domestic appliance industry. Despite its high surface quality, economies of scale make it cost-effective. Much of the bright-annealed material is of the ferritic type, i.e. it is essentially an iron-chromium alloy with an interesting price-to-quality ratio. Additionally, the most typical grade of this family, 430, is known to have particularly good reflectance properties.

Further development potential lies in the fact that the principle is also successfully applied to domestic hot water systems, water distillers, food dryers and large-scale community kitchens. Some of the biggest units can be found in India, where they produce hot water and steam for the preparation of three meals a day for a thousand people.

Summary and outlook

The Global Alliance for Clean Cookstoves calls for 100 million homes to adopt clean and efficient stoves and fuels by 2020. Stainless steel is an attractive material. For low-income families, the purchase of a clean cooking stove is a major investment. For this reason, the stove should be as durable as possible. Austenitic stainless steels have excellent formability and weldability. Lower-cost chromium-manganese austenitic grades and iron-chromium ferritic types are available to make high-quality cooking stoves affordable. Besides these proven alloys, the use of basic 12% Cr stainless steels is being investigated, which could also contribute to an increase of the market share of stainless steel. Among the physical properties, the reflective characteristics of mirror-like surfaces open up potential of stainless steel in solar cooking.

International Stainless Steel Forum (ISSF)

Rue Colonel Bourg 120
B-1140 Brussels, Belgium

T: +32 2 702 89 15
F: +32 2 702 89 12
E: issf@issf.org

www.worldstainless.org