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Development Of Materials And Processing Technology For Rural Blacksmiths: A Package

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ABSTRACT: Significant increase in agriculture products has been achieved in India through many avenues like use of better seeds, fertilizer, and irrigation yet less attention has been paid on improvement of the agriculture tools. Better tools and implements accelerate the agriculture production and for this genuine sources of raw materials for implements are in demand. Considerable research work at National Metallurgical Laboratory (NML), Jamshedpur has proved the utility of improved agriculture tools. The traditional practice of rural blacksmiths for producing the tools is being challenged by the growing industries surrounding the villages. Modern industries at the urban sector have lured the rural youths to fill their pockets by the moderate pay packets. So they are eager to switch over to urban side leaving their traditional trades. Since a few of them are succeeded to get absorbed in the modern industries, most of them are forced to return to their villages and here comes the means of survival with the traditional trades unless the production technique is enhanced/updated. Various problems regarding raw materials, education in connection with forging, design of implements and their heat treatment have been studied. Major phase of work, carried out at NML was to provide technology for achieving suitable raw materials by back yard steel melting technique and establishment of appropriate forging and heat treatment schedule to meet the specified standards. To provide technological support/ back up to practising blacksmiths of rural sectors, NML has assessed the quality of existing tools and implements and suggested methods for life improvement. Keeping in view the economics, NML has developed a low cost fuel-efficient furnace with a marginal alteration of the existing (Mother earth) hearth furnace used by the rural blacksmiths. The efficiency of the furnace has been enhanced distinctively by reducing convective and radiative heat losses by controlling the pre heated air and natural airflow ratio through the blower. This furnace has such a design that the same can be used for heat treatment of the tools. Simultaneously, a manually operated mechanical hammer is also developed for sledging purpose. With this, blacksmiths can continue the forging operation single handedly with substantial ease and increased productivity.

BACKGROUND

Agricultural tools and implements are primarily made by hand forging in rural sectors, irrespective of regions. The noteworthy difference is the varying raw materials for their product.To assess the quality of the products, a large number of different varieties of tools were collected from NGOs spread all over India for investigation in respect of chemical constituents, hardness and microstructural characteristics. Few of the products meet the Bureau of Indian Standard (BIS) specification. The primary reason being, the available raw material is usually of low carbon grade, while different product need higher carbon levels (0.6 to 1.0%) in order to satisfy BIS specification. Under these circumstances, it was felt necessary that a simple method of melting be introduced at the blacksmith's end where he can produce his own raw material having desired carbon level (backyard steel). The lack of BIS specified hardness as observed on their product also necessitated to develop a heat treatment schedule for high carbon steel to produce quality products at artisan's end. The traditional blacksmith's hearth furnace observed to be uneconomical and suffers from high fuel consumption. Moreover, while shaping to products, the operation by heavy sledgehammer adds to their drudgery. Thought was, therefore, paid to bring improvement on these aspects.

Development Model

The development of a total technology package for rural blacksmiths, resulted from execution of three projects, sponsored by the Science and Society Division of Department of Science and Technology (DST), New Delhi, and coordinated by the Centre for Technology and Development (CTD), New Delhi, under All India Coordinated Programme (AICP) on blacksmithy. The development requiring several aspects to be covered needed direct participation of Scientists and staff members from different divisions of NML as well as NGOs and their constituent field groups.

TECHNOLOGY PACKAGE

Production And Standardisation Of Desired Carbon Raw Materials

The present work envisage thermit melting of ferrous materials in batches with R&D back up in respect of size, proportion of the charge and melting equipment to arrive at desired carbon level. A correlation in respect of carbon level and mechanical processing has also to be established. Thus, the objectives of the project have been:

i) to prepare appropriate charge material for obtaining desired carbon level.
ii) to establish a simple melting route to prepare ingots/bars which can be mechanically worked to shapes.
iii) to establish appropriate mechanical processing parameters to achieve high quality of the product.

Keeping the objective in view, the work envisaged to prepare the steel blocks (Figure-1&2) with varying carbon level as desired, by alumino thermit melting (which does not require electric power).

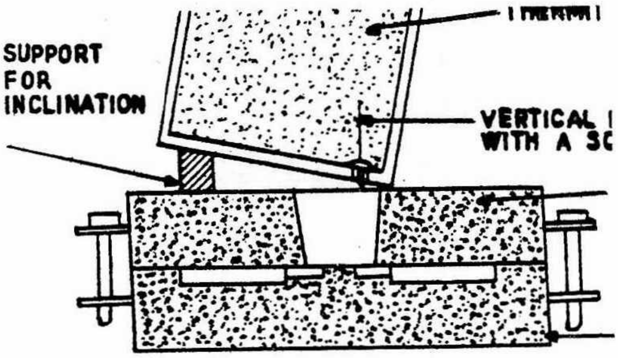

Figure 1. Schematic Figure of obtaining metal block from thermit melting

Figure 2. Thermit Melting (Backyard Steel)

The outcome of the work recommend a thermit mix containing aluminium powder and blue dust as major constituents (definite proportion). The basic mixture has a carbon level of 0.2%. The carbon can be varied by the addition of judicious proportion of cast iron and mild steel chips/turnings to the basic mixture. The yield of metal from the basic mix had been 40%. The addition of chips/turnings increased the overall yield to as high as 60% in carbon levels of 0.4%, 0.6% and 1%. The prepared blocks were successfully forged in a 0.5 T capacity pneumatic hammer in the laboratory scale trials. The workmanship and crafts are, however, different in the field and largely dependent on the skill of the individual. Thus it is necessary to undertake workability study in collaboration with identified NGOs engaged in making of tools by blacksmithy. The artisans, deputed from Vikash Bharti, Bishunpur (Ranchi); SVGSS, Belur math, Howrah and Pallishri, Bhubaneswar could successfully produced agriculture implements and household utility items from the thermit melted carbon steel.

Forging & Heat Treatment Schedule

Compared to conventional raw materials, the forging schedule is slightly tricky in this case, as it requires cast structure to be broken first. Based on the experimentation and practical working by artisans, a forging schedule as well as a heat treatment schedule has been established for comparatively high carbon steel blocks.

<u>FORGING SCHEDULE</u>

Casting (0.7% to 1.0%C steel)

↓

Soak at 850-950°C

↓

5% deformation
Apply light blows

↓

Reheat at 850-950°C

↓

10% deformation
Apply light blows

↓

Reheat at 850-950°C

↓

10% deformation - apply light blows

↓

Final shaping at 750-950°C

<u>HEAT TREATMENT SCHEDULE</u>

0.7 to 1.0% Carbon steel

↓

Soak at 750-780°C
Soaking time: 60min /25mm thickness

↓

Quench in oil/water with
continuous stirring

↓

Reheat at 250°C
immediately after quenching
Reheating time: 60mm/25mm thickness

Fuel Efficient Furnace

The package also provides a low cost fuel efficient furnace, incorporating modifications on the existing blacksmiths' hearth furnace (Figure 3 &4). The efficiency of the furnace has been enhanced distinctively by reduction of convection and radiation heat losses, controlling the air flow and preheating the feed air.

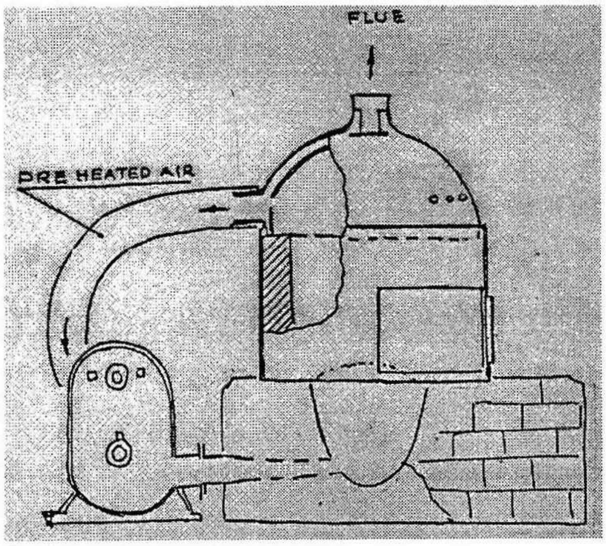

Figure 3. Schematic sketch of the fuel efficient furnace

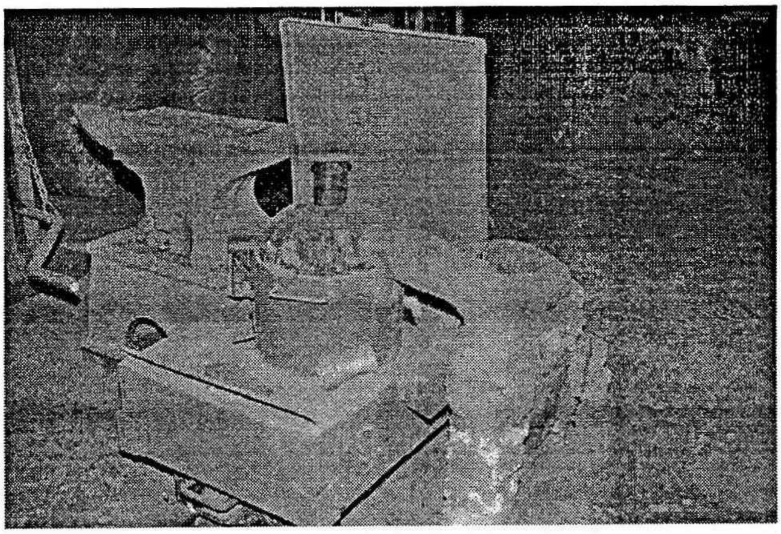

Figure 4. Photograph of a furnace fabricated at the Laboratory

Features:

- $2/3^{rd}$ reduction in fuel
- 50% flue utilisation
- Temp. of inlet air: 120-200°C
- Portable

The conventional furnace is enclosed with a mild steel shell lined with locally available refractories such as rice husk ash and clay. Over the shell, a specially designed double-walled earthen hood is placed, having top as well as side outlets. The side outlet is connected to blower through earthen ducts, facilitating recycling of the flue gas. The top outlet acts as temperature regulator either letting the escape of flue or by partial closing.

At the bottom of the top outlet, a specially designed heat deflector is fitted through which convective heat is regulated. The earthen hood has a few vents on the periphery of the outer surface for air-inlet. The vent holes serve to regulate the desired quantity of heat, thus stagnating the temperature for quite some time. This enhances the possibility of using the furnace for heat treatment purpose also.

Mechanical Hammer

With an objective of performing forging operation single-handedly with considerable ease, a manually operated mechanised hammer developed for the purpose is also a constituent of the package. Based on the principle of leverage, hammer is capable to provide sufficient impact energy to the job placed on the anvil. The hammer has such a flexibility that depending on the requirement, by only controlling the impact energy through pedal, the purpose of both small and big hammer can be utilised simultaneously. An adjustable counter weight facilitates the return of hammer in steady position immediately after impact as well as it controls energy inputs to the work piece (Figure 5 &6).

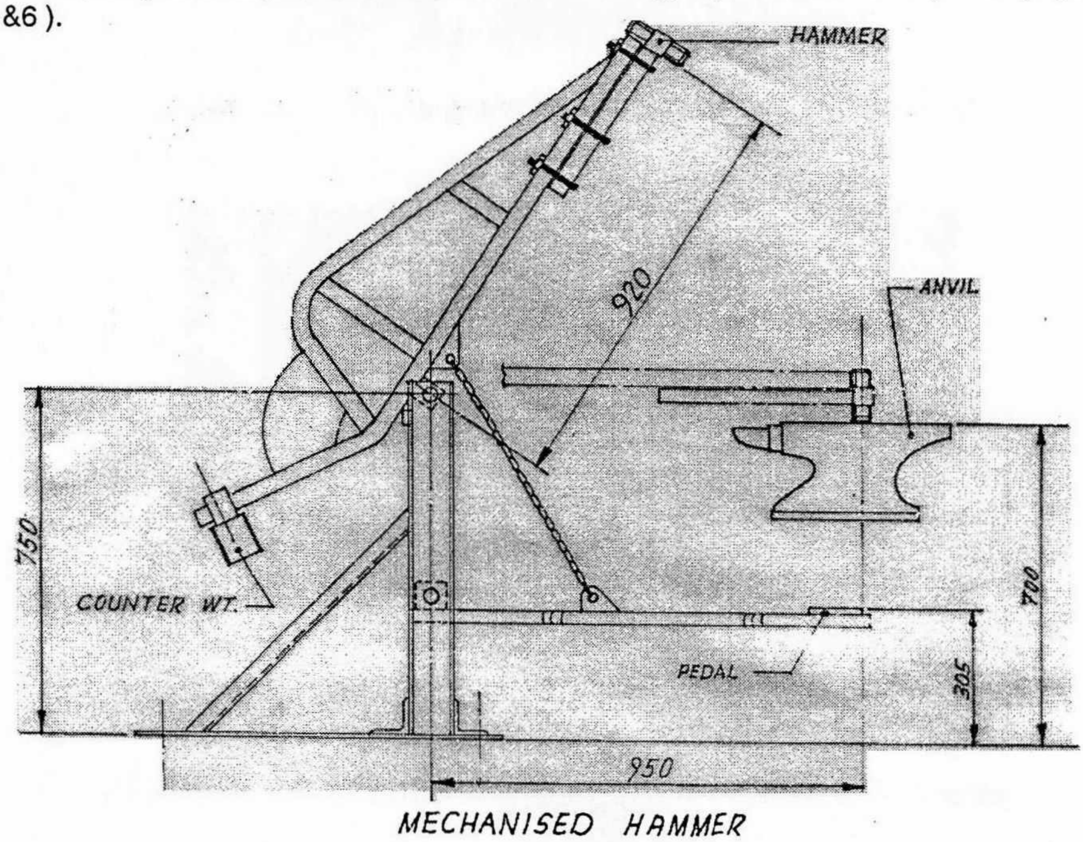

Figure 5. Schematic sketch of Mechanical Hammer

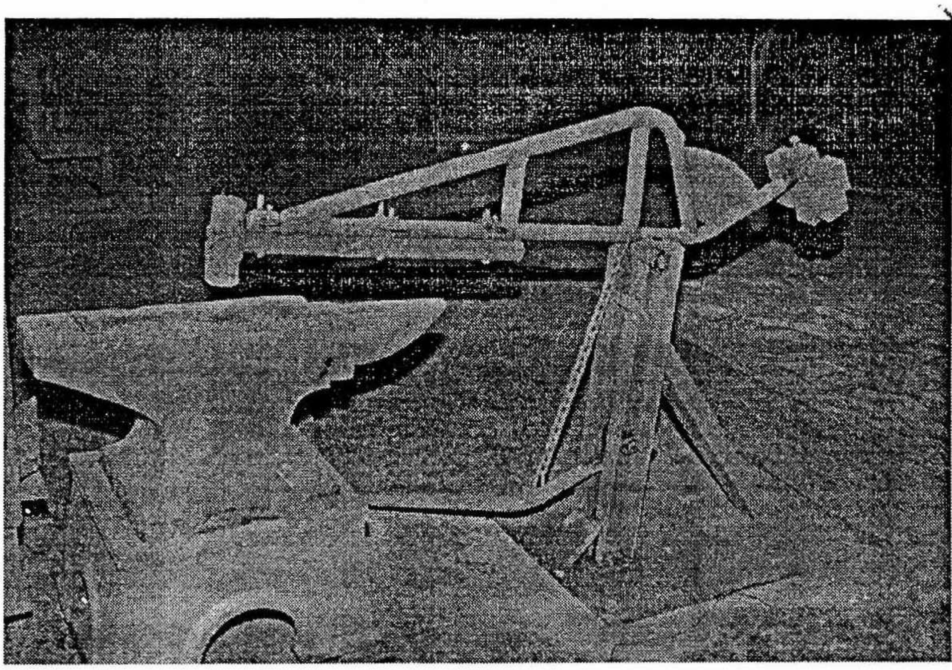

Figure 6. Mechanical Hammer fabricated at NML

INNOVATIVE ASPECTS OF THE TECHNOLOGY

The developed products are a merger of basic science and technology.

Backyard Steel Making

The production and standardisation of raw materials_for artisanal blacksmiths in rural sectors, makes use of alumino-thermic technique which aims at the production of metal from its oxide by reduction with aluminium powder using exothermic heat of reaction for smelting purposes.

Basically it is the 'ingenuity' to adopt this principle for production of 'required carbon metal blocks/strips', which can even be produced at the courtyard of an artisans. The enthusiast participants in the training and demonstration programme have named this process as 'backyard steel'.

Fuel Efficient Furnace

In the development of fuel-efficient furnace, following were considered

I. Utilisation of waste heat
   - Recycling part of the flue since this contains sufficient excess air, thereby reducing the heat carried away with excess air

- Due to near complete combustion of the fuel, CO emission in flue is minimum.
- Controlling of the feed air by adjusting the opening of the hole on the outer periphery of the hood to maintain optimum oxygen content in combusting air
- Introduction of number of baffles in the gap between double walled hood to increase Reynolds number for effective heat transfer for preheating of feed air

II. Reduction in heat loss due to convection and radiation by providing appropriate enclosure with predetermined geometry to conventional hearth type furnace

Mechanical Hammer

In the development of mechanical hammer, the following have been considered

- Concept of leverage has been adopted for ease of operation and to achieve better mechanical advantage
- Adjustable counter weight arm for different hammer weight facilitating swing back in a desired time set
- "Effort" is on foot pedal for impact transfer to be more effective and comfortable. Moreover the reactive hammering thrust is not being experienced by the operator

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