

## **TECHNOLOGY FOR BIO-MASS HANDLING AND COMBUSTION**

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### **INTRODUCTION:**

THIS PAPER FOCUSES ON BIO-MASS HANDLING AND COMBUSTION FOR THE INDIAN CONTEXT. BASICALLY BIO-MASS IS STORED SOLAR ENERGY. BIO-MASS BASED POWER GENERATION IS BEING ACCORDED IMPORTANCE ALL OVER THE WORLD. THE BIO-MASS BASED POWER PROJECTS ARE SUPPOSED TO BE BENEFICIAL ON TWO COUNTS - THEY PROVIDE AN ECOLOGICALLY ACCEPTABLE MEANS FOR DISPOSAL OF UNWANTED CROP RESIDUES AND THEY DO NOT ENHANCE THE EMISSION OF GREENHOUSE GASES. IN INDIA, THE **MINISTRY OF NON-CONVENTIONAL ENERGY SOURCES** HAS BEEN PROMOTING PRODUCTIVE USE OF BIO-MASS FOR APPLICATIONS WHICH INCLUDE POWER GENERATION. THE MINISTRY HAS BEEN IMPLEMENTING PROGRAMMES FOR PROMOTION OF DIRECT COMBUSTION, GASIFICATION, BRIQUETTING AND CO-GENERATION TECHNOLOGIES.

THE BIO-MASS CAN BE BROADLY CLASSIFIED AS WOODY AND NON-WOODY. WOODY BIO-MASS IS ESSENTIALLY THE SOLID STALK OF THE MAIN TRUNK AND BRANCHES IN TREES AND PLANTS AND IS DENSE AND HAS LITTLE ASH. EVEN THOUGH WOODY AND NON-WOODY IS IMPORTANT, IT IS USEFUL TO RECOGNISE THAT THE COMPOSITION IS NEARLY SAME OVER A NUMBER OF SPECIES. STRUCTURALLY BIO-MASS IS COMPOSED OF ABOUT 50% CELLULOSE, 25% HEMICELLOSES AND BREAKDOWN EASIER THAN LIGNIN, THERMALLY AS WELL AS BACTERIALLY.

THE VARIOUS TYPES OF BIO-MASS ARE DEPICTED WITH ITS ENERGY VALUES. IT WILL BE EXHAUSTIVE TO DEAL WITH ALL THE BIO-MASS COMBUSTION AND HANDLING CHARACTERISTICS IN THIS PAPER AND HENCE THE PAPER DEALS WITH WOOD, BAGASSE, RICE HUSK AND GROUNDNUT SHELL WHICH HAS BEEN ACCEPTED AS COMMERCIALY VIABLE BIO-MASS FUELS.

### **BIO-MASS COMBUSTION:**

IN ORDER TO UNDERSTAND THE COMBUSTION OF WOOD, BAGASSE, RICE-HUSK AND GROUND NUT SHELL, IT IS ESSENTIAL TO KNOW ABOUT THE COMBUSTION PROPERTIES OF THESE FUELS.

### **PROPERTIES OF BIO-MASS FUEL:**

THE MAIN PROPERTIES OF BIO-MASS FUEL FOR COMBUSTION TO BE SEEN ARE THE PERCENTAGE OF VOLATILES, CARBON, MOISTURE AND ASH. THE P-3 DEPICTS THESE VALUES FOR WOOD, BAGASSE, RICE-HUSK AND GROUND NUT SHELL. FEW OTHER PROPERTIES THAT INFLUENCE BIO-MASS COMBUSTION ARE THE CALORIFIC VALUE & BULK DENSITY. SOME OF THE ADVANTAGES AND DIS-ADVANTAGES OF UTILIZATION OF BIO-MASS FOR POWER GENERATION ARE SHOWN IN P-4.

### **FUEL SELECTION FOR PLANT GOVERNING PARAMETERS:**

THE BASIC QUESTION THAT ARISES WHILE SELECTING THE FUEL IS TO UTILIZE BIO-MASS IN COMBUSTION ROUTE OR GASIFICATION ROUTE. **AVANT-GARDE'S** RICH EXPERIENCE IN BIO-MASS UTILIZATION SHOWS THAT COMBUSTION ROUTE IS BEST UTILIZED IN THE PRESENT INDIAN SCENARIO. **AVANT-GARDE** HAS ADDED 90 MW OF BIO-MASS POWER TO THE STATE GRID THROUGH CO-GENERATION ROUTE WITH BAGASSE AS THE BIO-MASS FUEL. THE FOLLOWING ARE THE FACTORS INFLUENCING THE SELECTION OF FUEL FOR PLANT GOVERNING PARAMETERS:

- SITE STORAGE AREA FOR FUEL
- MODE OF TRANSPORT
- COST OF FUEL (EX-GODOWN)
- MINIMUM QUANTITY AVAILABLE
- SIZE OF FUEL
- SEASON IN WHICH FUEL IS AVAILABLE
- FUEL HANDLING SYSTEM FOR BOILER
- FIRM AGREEMENT WITH VENDORS

### **TECHNOLOGICAL ASPECTS OF COMBUSTION:**

THE COMBUSTION TECHNOLOGY OPTIONS FOR BIO-MASS FUEL ARE AS BELOW:

### **THERMO-CHEMICAL CONVERSION:**

- DIRECT COMBUSTION: THERMAL DECOMPOSITION OF ORGANIC MATTER IS CARRIED-OUT IN THE PRESENCE OF EXCESS AIR, LIBERATION HEAT AND LEAVING BEHIND INCOMBUSTIBLE ASH.  
FUEL + AIR      —————> HEAT + ASH + INERT GASES.

THIS DIRECT COMBUSTION OF BAGASSE HAS BEEN COMMERCIALY ESTABLISHED. THE TYPICAL COMBUSTOR FOR BAGASSE IS SHOWN IN P-5. THE GRATE USED FOR BAGASSE IS OF TRAVELLING TYPE. OTHER METHOD FOR BIO-MASS DIRECT COMBUSTION IS THROUGH

FLUIDISED BED COMBUSTION (FBC). IT IS TO BE NOTED THAT BAGASSE HAS NOT BEEN TRIED SUCCESSFULLY IN FBC, WHEREAS THE RICE-HUSK IS EFFECTIVELY BURNT IN FBC. THE GROUND NUT SHELL AND WOOD CAN BE BURNT BOTH IN GRATE AS WELL AS IN FBC.

- GASIFICATION: THERMAL DECOMPOSITION OF ORGANIC MATTER IN THE PRESENCE OF LIMITED SUPPLY OF AIR OR OXYGEN TO PRODUCE COMBUSTIBLE GASES THUS CONVERTING CALORIFIC VALUE OF ORGANIC MATERIAL INTO A GASEOUS ENERGY CARRIER.
- PYROLYSIS: PYROLYSIS REFERS TO COMBUSTION IN A DEFICIENT SUPPLY OF AIR/OXYGEN. THIS PROCESS PRODUCES THREE USEFUL FUELS-CHAR COAL, OIL & GAS.
- LIQUEFACTION.
- THERMAL CATALYTIC CRACKING.

### **BIOLOGICAL CONVERSION:**

BIOLOGICAL PROCESS INVOLVE ENZYMATIC BREAKDOWN OF BIO-MASS BY MICRO ORGANISM AT LOW PRESSURE AND LOW TEMPERATURE.

- AEROBIC FERMENTATION.
- ANAEROBIC FERMENTATION.

### **COMBUSTION SYSTEMS:**

THE VARIOUS TECHNOLOGICAL ASPECTS OF COMBUSTION SYSTEMS ARE DISCUSSED ABOVE AND THE SPECIFIC FOCUS FOR COMBUSTION OF WOOD, BAGASSE, RICE-HUSK AND GROUND NUT SHELL ARE DEALT BELOW.

- SINCE WOOD BEING A COMMON FUEL AVAILABLE ALL-OVER, THE COMBUSTION SYSTEMS HAS BEEN ESTABLISHED WELL IN PAST AND IT WILL BE TOO EXHAUSTIVE TO LIST OUT THE COMBUSTION SYSTEMS FOR WOOD HERE.
- BAGASSE IS A CANDIDATE FUEL AND BEING TAPPED EXTENSIVELY BY SUGAR AND PAPER INDUSTRIES AS A BIO-MASS FUEL. SINCE, THESE INDUSTRIES REQUIRE PROCESS STEAM APART FROM ELECTRICAL POWER. THE COGENERATION MODE IS WIDELY ACCEPTED. AVANT-GARDE IS A PIONEER ORGANISATION AND HAS COMMERCIALY DESIGNED AND EXECUTED THE COMBUSTION SYSTEM FOR BAGASSE. THE COMBUSTION OF BAGASSE IS ACHIEVED BY PARTIAL SUSPENSION BURNING. THIS IS ACCOMPLISHED BY INJECTION THE FUEL INTO THE FURNACE SO THAT LIGHTER PARTICLES BURN IN SUSPENSION AND THE HEAVIER PARTICLES FALL TO A MOVING GRATE WHERE THEY CONTINUE TO BURN. AVANT- GARDE HAS DEVELOPED

CONTINUOUS BAGASSE FEEDING SYSTEM WHICH IS DISCUSSED IN DETAIL UNDER THE TITLE BIO-MASS FUEL HANDLING. THE P-7 SHOWS TYPICAL COGENERATION SCHEME.

- RICE HUSK IS ANOTHER ALTERNATE BIO-MASS FUEL AND THE COMBUSTION IS THROUGH FLUIDISED BED BOILER. FLUIDISED BED COMBUSTION IS A METHOD OF BURNING CRUSHED FUEL IN THE BLOWING UP FROM UNDERNEATH. THE BED MATERIALS ARE KEPT IN SUSPENSION BY THE SAME AIR THAT FEEDS THE BURNING PROCESS. **AVANT-GARDE** HAS DESIGNED RICE-HUSK FIRED BOILER FOR VARIOUS INDUSTRIES.
- GROUND NUT SHELL IS BIO-MASS FUEL WITH PROMISING FUTURE AND COMBUSTION OF GROUND NUT SHELL CAN BE DONE WITH ABOVE BED DIRECT COMBUSTION OR THROUGH FLUIDISED BED COMBUSTION. THE SELECTION OF ANY ONE OF THE ABOVE COMBUSTION PROCESS FOR GROUND NUT SHELL IS DEPENDENT PURELY ON CIRCUMSTANTIAL ASPECTS. **AVANT-GARDE** HAS IN-HOUSE DESIGN DEVELOPED FOR A 3.5 MW BIO-MASS BASED POWER PROJECT IN KARNATAKA FOR A TEXTILE INDUSTRY.

HAVING DEALT THE COMBUSTION SYSTEMS IN DETAIL, **AVANT-GARDE** SHARE THEIR EXPERIENCE WITH SPECIFIC FOCUS. THE P-7 SHOWS TYPICAL STEAM GENERATING CAPACITY WITH BAGASSE. THE P-8 AND P-9 SHOWS STEAM TURBINE CYCLE EFFICIENCIES AND SPECIFIC STEAM CONSUMPTION IN POWER TURBINES RESPECTIVELY. THE P-10 SHOWS THE COST OF ELECTRICITY FOR THE COGENERATION PLANT. IT MAY BE NOTICED THAT HIGH PRESSURE STEAM COMBUSTION SYSTEMS PROVIDES BETTER EFFICIENCY. **AVANT-GARDE** IS THE FIRST ORGANISATION IN INDIA THAT DESIGNED, DEVELOPED AND COMMISSIONED HIGH PRESSURE BOILER FOR BAGASSE BASED COGENERATION PROJECT AND OBTAINED THE BEST CONSULTANCY AWARD FOR THIS COGENERATION PLANT FROM CDC. RECENTLY, **AVANT-GARDE** WAS ALSO CROWNED BY **IREDA** FOR THE DECADE OF CONSULTANCY SERVICE IN NON-CONVENTIONAL ENERGY SYSTEMS. **AVANT-GARDE** HAD ALSO RECEIVED BEST CONSULTANCY AWARD FOR THE PAST THREE YEARS FROM “CONSULTANCY DEVELOPMENT CENTRE” (CDC) FOR BAGASSE BASED COGENERATION PROJECTS IN SUGAR INDUSTRIES.

#### **BIO-MASS STORAGE AND HANDLING:**

THE VITAL PART OF A BIO-MASS BASED PROJECT IS BIO-MASS STORAGE AND HANDLING. DUE TO POOR BULK DENSITY, THE VOLUME OF BIO-MASS TO BE STORED AND HANDLED POSES CHALLENGES. ANOTHER

ASPECT IS ITS CONTINUOUS AVAILABILITY AT PROJECT SITE. HOWEVER THE BIO-MASS POWER PROJECT ARE NORMALLY DESIGNED TO HANDLE MULTI-FUEL (BIO MASS) ALONG WITH CONVENTIONAL FOSSIL FUELS LIKE COAL & LIGNITE. THE REASON FOR DESIGNING THE COMBUSTOR FOR FOSSIL FUELS IN ADDITION TO BIO-MASS FUEL IS MAINLY TO BRING FUEL FLEXIBILITY FOR CONTINUOUS OPERATION OF THE POWER PLANT.

#### **BIO-MASS STORAGE:**

THE BIO-MASS BASED POWER PROJECTS ARE NORMALLY OPERATING FOR 7500 HOURS IN A YEAR. WHILE THERE ARE NO TECHNICAL RESTRICTIONS TOWARDS HIGHER AVAILABILITY, BIO-MASS SUPPLIERS MAY NOT BE WILLING FOR A LONG TERM FUEL SUPPLY AGREEMENT WITH POWER PROJECT PROMOTERS. ALSO, THE BIO-MASS IS WIDELY SPREAD ALL OVER AND THE COLLECTION AND TRANSPORTATION OF THE SAME TO THE PROJECT SITE IS TO BE ECONOMICALLY IMPLEMENTED. THE POTENTIAL OF AVAILABILITY OF BIO-MASS FUEL IS NOT THOROUGHLY ANALYSED AT TALUK LEVELS AND DATA SO FAR AVAILABLE ARE COLLECTED BASED ON OVERALL PRODUCTION OF CROP RESIDUES IN INDIA. THE MINISTRY OF NON-CONVENTIONAL ENERGY (MNES) IS NOW ASSESSING TALUK LEVEL BIO-MASS AVAILABILITY STATE WISE.

CONSIDERING THE ABOVE, 15 DAYS OF STORAGE OF BIO-MASS IS PRESENTLY BEING ADVISED FOR BIO-MASS BASED POWER PROJECTS. **AVANT-GARDE** HAS CONDUCTED A STUDY FOR A 3.5 MW GROUND NUT SHELL BASED POWER PROJECT IN KARNATAKA. THE P-11, 12 & 13 SHOWS THE DETAILS. THE ECONOMICS SHOWS THAT THE STORAGE OF BIO-MASS FUEL FOR MORE THAN 15 DAYS IS POSING PROBLEMS OF SPACE AND THE COST OF BIO-MASS FUEL IS TO BE EVALUATED VERY CAREFULLY.

ALSO, COVERED STORAGE OF BIO-MASS IS A MUST AND STORING. STACKING AND RECLAIMING OF BIO-MASS FUEL IN COVERED STORAGE REQUIRE CAREFUL ATTENTION AND SPECIAL DESIGN. PROPER FIRE PROTECTION SYSTEMS AS PER STATUTORY REGULATIONS ARE TO BE FOLLOWED. IT IS ADVISABLE TO KEEP THE STORAGE OF BIO-MASS FUEL AS NEAR TO THE BOILER AS POSSIBLE AND THUS THE COST OF HANDLING THE BIO-MASS FUEL CAN BE MINIMIZED.

BALED BIO-MASS PROVIDES EASE OF TRANSPORT AND HENCE IS DESIRABLE. THE CONCEPT OF BALING THE BIO-MASS FOR TRANSPORT CALLS FOR SPECIAL ATTENTION WHEN BIO-MASS FUEL IS CONSIDERED FOR THE POWER PROJECT. WITH THE RECENT ADVANCEMENT IN TECHNOLOGY, MECHANIZED BALING OF BIO-MASS FUEL IS GIVEN MORE IMPETUS OVER MANUAL BALING. **AVANT-GARDE** IS FOCUSING MORE IMPORTANCE TOWARDS MECHANIZED BALING.

## **BIO-MASS HANDLING:**

AS DEPICTED EARLIER, THE BIO-MASS FUELS ARE HAVING POOR BULK DENSITY THAT MAKES THEM DIFFICULT TO HANDLE. THE CONVENTIONAL BELT CONVEYING SYSTEMS ARE WIDELY ADOPTED UPTO THE BOILER FRONT. IN ORDER TO ENSURE THAT THE BOILER IS NOT STARVING OF FUEL, HUGE SILOS ARE ENVISAGED BEFORE THE FUEL IS PUT INSIDE THE FURNACE ALSO, THE STEAM PRESSURE AND TEMPERATURE ARE TO BE CONTROLLED IN HIGH PRESSURE STEAM SYSTEMS FROM SAFETY POINT OF VIEW. THE P-14 DEPICTS A TYPICAL FUEL HANDLING SYSTEM FOR A 3.5 MW BIO-MASS POWER PLANT.

PRESENTLY, IN THE SUGAR PLANTS USING HIGH PRESSURE BOILERS, BAGASSE IS DIRECTLY FED FROM THE MILL WHICH CAUSES FREQUENT BOILER STEAM OUTLET PRESSURE/TEMPERATURE FLUCTUATION EVEN DUE TO SMALL FLUCTUATION IN CRUSHING, ESPECIALLY WHEN THE PLANT IS CONNECTED TO THE GRID. DURING MILL STOPPAGES, THERE IS A TIME LAG BEFORE BAGASSE IS BACK FED AND IN THIS PERIOD THE BOILER PRESSURE DECREASES CAUSING DROP IN TURBINE INLET STEAM CONDITION WHICH INTERRUPTS THE POWER GENERATION.

**AVANT-GARDE** HAS DEVELOPED A CONTINUOUS BAGASSE HANDLING SYSTEM, WHICH IS OPERATING SUCCESSFULLY IN MANY SUGAR PLANT INSTALLATIONS. THE P-15 DEPICTS A TYPICAL CONTINUOUS BAGASSE HANDLING SYSTEM FOR A 30 MW BAGASSE BASED COGENERATION PROJECT. **AVANT-GARDE** ALSO DEVELOPED SIMILAR SYSTEM FOR HANDLING GROUND NUT SHELL AND WOOD CHIPS.

## **CONCLUSIONS:**

POWER IS THE MOST ESSENTIAL INPUT FOR INDUSTRIALISATION AND IT IS INDEED THE FULCRUM ON WHICH THE FUTURE PACE OF GROWTH AND DEVELOPMENT OF OUR COUNTRY RESTS. BIO-MASS HAS TRADITIONALLY BEEN THE MOST IMPORTANT SOURCE OF ENERGY IN RURAL AREAS AND THE MAJOR FUEL EVEN IN THE URBAN AREA. THE TECHNOLOGY FOR COMBUSTION AND HANDLING OF BIO-MASS IS PROVEN AND **AVANT-GARDE** HAS ALL IN-HOUSE EFFORTS TO **DELIVER A BIO-MASS POWER PROJECT FROM CONCEPT OF COMMISSIONING.**