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Design and fabrication of a bulk paddy sampling equipment

(Reka bentuk dan fabrikasi peralatan untuk persampelan padi pukal)

O. Muhamad Isa*

Key words: design, fabrication, bulk paddy equipment, automation

Abstrak

Dalam urusan jual beli padi di kilang beras, proses penentuan kualiti padi perlu dilaksanakan dengan pantas dan tepat supaya petani dapat menerima pembayaran dengan adil dan segera bagi hasil mereka. Dalam kes padi pukal yang dibawa oleh trak, sampel padi pada beberapa aras tertentu perlulah diperoleh dahulu. Kemudian padi ini digaul dan saiz sampel dikurangkan untuk menghasilkan kuantiti dan keseragaman padi yang sesuai untuk penggredan. Alat proba pendek sedia ada yang digunakan untuk mengambil sampel padi di dalam guni didapati tidak sesuai digunakan pada padi pukal. Walaupun reka bentuk proba ini boleh dipanjangkan tetapi kekuatan diperlukan untuk membenam proba ke dalam padi pukal.

Sebuah peralatan untuk mempercepat pengambilan sampel padi pukal di dalam trak telah direka bentuk dan dibina. Peralatan ini dapat mengambil sampel padi pukal di lokasi tengah dan empat penjuru trak. Berat sampel padi ialah 2.5 kg dengan mengambil masa 2–3 minit bergantung pada kecekapan operator. Sebahagian daripada proses pembangunan peralatan ini merangkumi reka bentuk dan ujikaji alat kawalan menggunakan pemproses mikro untuk membolehkan peralatan berfungsi secara automatik. Seterusnya, alat penggaul padi bermotor yang boleh menghasilkan kuantiti dan keseragaman padi yang sesuai untuk penggredan telah juga direka bentuk. Alat ini dapat menghasilkan sampel padi yang seragam dengan melaraskan masa alat beroperasi kepada 99 saat dengan kelajuan motor 140 pusingan seminit.

Abstract

In paddy procurement transaction at the rice mill, fast and accurate quality determination process of the paddy is needed so that farmers are quickly and fairly paid for their produce. In the case of bulk paddy delivered by truck, it is necessary that representative samples over depth of bulk paddy are taken first at predetermine locations. Then these paddy samples are mixed uniformly and reduced to proper size for use in grading exercise. The existing short length hand type probe commonly used to sample sack paddy is unsuitable for taking representative samples throughout the depth of the bulk paddy. Even the probe can be made longer, but it requires a great effort to insert throughout the bulk paddy.

*Strategic, Environment and Natural Resources Research Centre, MARDI Headquaters, P.O. Box 12301, 50774 Kuala Lumpur, Malaysia
Author's full name: Muhamad Isa Othman

An equipment for quick sampling of bulk paddy in local truck size was designed and fabricated. It was designed for deep sampling of the bulk paddy at the centre and four corner locations of the truck. The amount of paddy sample was 2.5 kg with the overall time taken 2–3 minutes depending on the operator skill. Part of the development work on this equipment was concentrated on designing and testing of the microprocessor based controller to automate the sampling operation of the bulk paddy on the truck. Subsequently a motorised paddy mixer capable of producing uniform and proper weight of paddy sample for grading had also been designed. The device could produce uniform paddy sample by setting its mixing time to 99 seconds with the motor speed of 140 rpm.

Introduction

The prevailing practice of post harvest paddy handling contributes to high grain losses due to frequent transferring of grain involving large bagging units during transportation from field to a milling complex. It is a time consuming operation and requires high labour input. The adoption of bulk handling technology using trucks for the transportation of harvested paddy is regarded as an efficient system to overcome the problem besides reducing direct handling cost (Ahmad 1984; Bramall 1987). Bulk paddy handling technology has been adopted in some rice schemes in Malaysia.

In bulk system, an improved handling technology in the form of modifications to the present bagged handling facilities and the introduction of new equipment for receiving bulk harvested paddy in trucks transported from the farm have to be made at the rice milling complex. An important operation associated with the bulk handling is the sampling of bulk paddy in truck and taking the grain samples into a laboratory where the samples are mixed and reduced in size for grading purposes. To have representative samples of bulk paddy, it requires a hardware that is able to take paddy samples at predetermined locations throughout the depth of the bulk paddy. In addition, this operation needs to be done quickly so that the paddy procurement transaction process in the rice mill is not delayed.

A common short hand type probe used to sample paddy in gunny sack is not suitable for sampling paddy over the bulk paddy depth inside the truck. Although a longer probe is available, it requires a great effort to insert it in the bulk paddy. On the other hand, the imported bulk sampler equipment used in some rice complexes are bulky and expensive, and they are made for handling large scale bulk grains of different types and moisture content from the local condition (Newman 1987). An equipment that is capable of taking sample throughout the depth of the bulk paddy at different locations in systematic manner and subsequently transports the grains to a mixer is envisaged as an efficient system for the bulk paddy sampling.

An equipment for samplings of bulk paddy delivered by trucks and motorised mixer for mixing paddy samples were developed between 1991 and 1994. The development of the bulk paddy sampling equipment composed of design and fabrication of a hydraulic actuated bulk paddy probe, probe transporter and installation of pneumatic equipment for conveying paddy samples to a collection box. Concurrently, a microprocessor based controller to automate operation of the equipment was also designed and tested.

Materials and methods

The description of paddy bulk sampling equipment

The bulk paddy sampling equipment is shown in *Plate 1*. The equipment is designed for sampling bulk paddy in trucks currently used by industry (Abdullah 1987).

It consists essentially of a hydraulic powered paddy deep probe, a probe transporter, a pneumatic suction pump, a collection box and a motorised paddy mixer. The probe transporter is mounted on to an 'A' steel frame bolted against concrete wall, while a collection box, control instrument and a motorised paddy mixer are located at a distance inside a laboratory. The transporter is mounted with the probe tip positioned slightly above the bulk paddy. The functions of the probe transporter are to carry the probe horizontally at the desirable sampling locations and to assist pushing the probe vertically throughout the depth of the bulk paddy. The bulk paddy sampling equipment should meet the following criteria:

- The probe can penetrate to 1.3 meters depth of bulk paddy and collect paddy samples at predetermined layer.
- The probe can be transported to the centre and four corners of the local trucks sizes in a manner shown in *Figure 1* in accordance to the ISA standard of bulk grain sampling on trucks.
- The probe can be installed and dismantled easily for repairing and replacement.
- The paddy samples collected by the probe can be conveyed into a collection box in a laboratory which is located at a distance from the sampling area.
- The machine should be operated automatically for rapid, accurate and consistent sampling task.

The operation of the equipment is performed by energising respective solenoids of hydraulic actuators and electrical motor of pneumatic pump manually, or it can be automated by using a suitable controller. In the case of an automatic operation, upon pressing the start button, the probe is pushed vertically into the depth of paddy until it reaches the lowest position set by a lower limit switch. The probe collects a specific amount of paddy samples and then pneumatically conveys it into a collection box. The probe is removed from the bulk paddy by lifting it to the highest position set by an upper limit switch and then it is brought to another location by a probe transporter for repetitive task. When sampling of paddy at all locations are completed, the probe transporter returns to a home position with the probe at the highest position providing

Plate 1. Bulk paddy sampler equipment

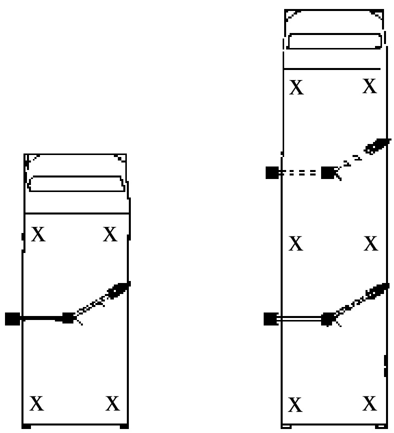

Figure 1. Bulk grain sampling locations on lorries

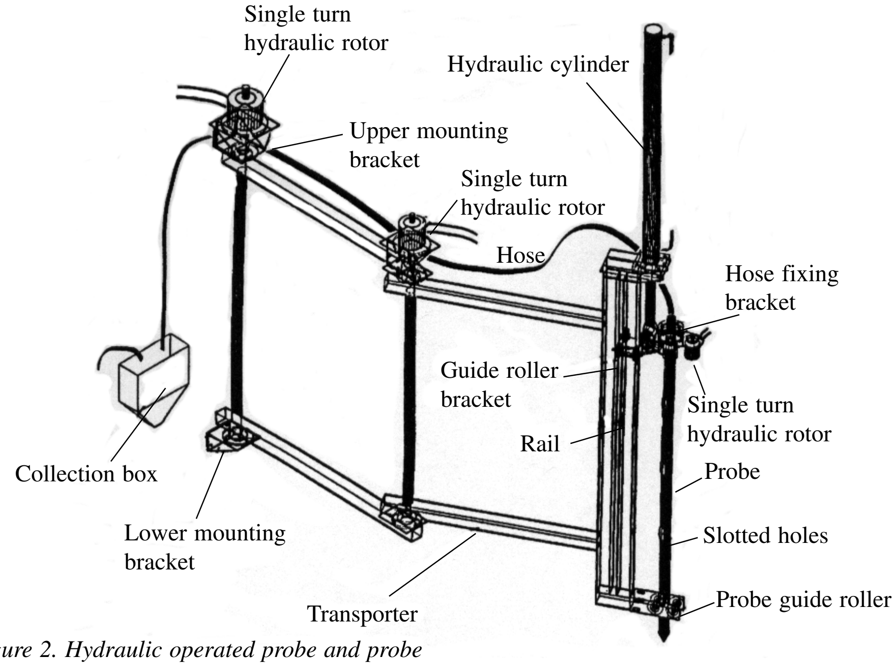

Figure 2. Hydraulic operated probe and probe transporter

enough clearance to another truck undertaking a similar bulk paddy sampling operation. The paddy sample at the collection box is poured into a motorised paddy mixer where it is uniformly mixed and then a proper paddy sample size can be extracted for grading.

Design of the paddy bulk sampling equipment

The hydraulic operated paddy probe The design of the hydraulically operated deep bin probe and the transporter mechanism components of the bulk paddy sampling equipment is shown in *Figure 2* while the cross sectional view of the probe is shown in *Figure 3*. The probe is 1.6 meters long and consisting of concentric outer and inner tubes. The tubes have five pairs of slotted hole equally spaced at alternate side of the tube wall. The inner tube freely rotates against the outer tube by means of a lower and an upper bearing and it is driven by a 135 degree turn hydraulic rotor through chain sprocket. The slotted holes of inner and outer tubes are aligned when the inner tube is rotated by 135 degree anticlockwise to allow the entry of grain inside the probe. An opposite turn of the inner tube closes the slotted holes thus preventing grain entry. A long double acting hydraulic ram mounted on the probe transporter is utilized to push down or lift up the probe over the bulk paddy. The vertical movement of the probe is guided by its upper roller device rolled over a vertical beam of the probe transporter and fixed lower roller device which rolled over the body of the probe. When the tip of the probe reaches the lowest set position, a hydraulic rotor twists the inner tube 135 degree anticlockwise to align the slotted holes for samples collection. An opposite turn of the rotor closes the slotted holes and the probe is lifted out of the bulk paddy until it reaches the highest set position.

Buckling of the probe is avoided by aligning slotted holes on the alternate side of the tube walls and with probe tip made of a cone shaped bullet to reduce drag over the bulk paddy. A high pneumatic suction of grain inside the probe is obtained by making two small holes at the cone bullet which

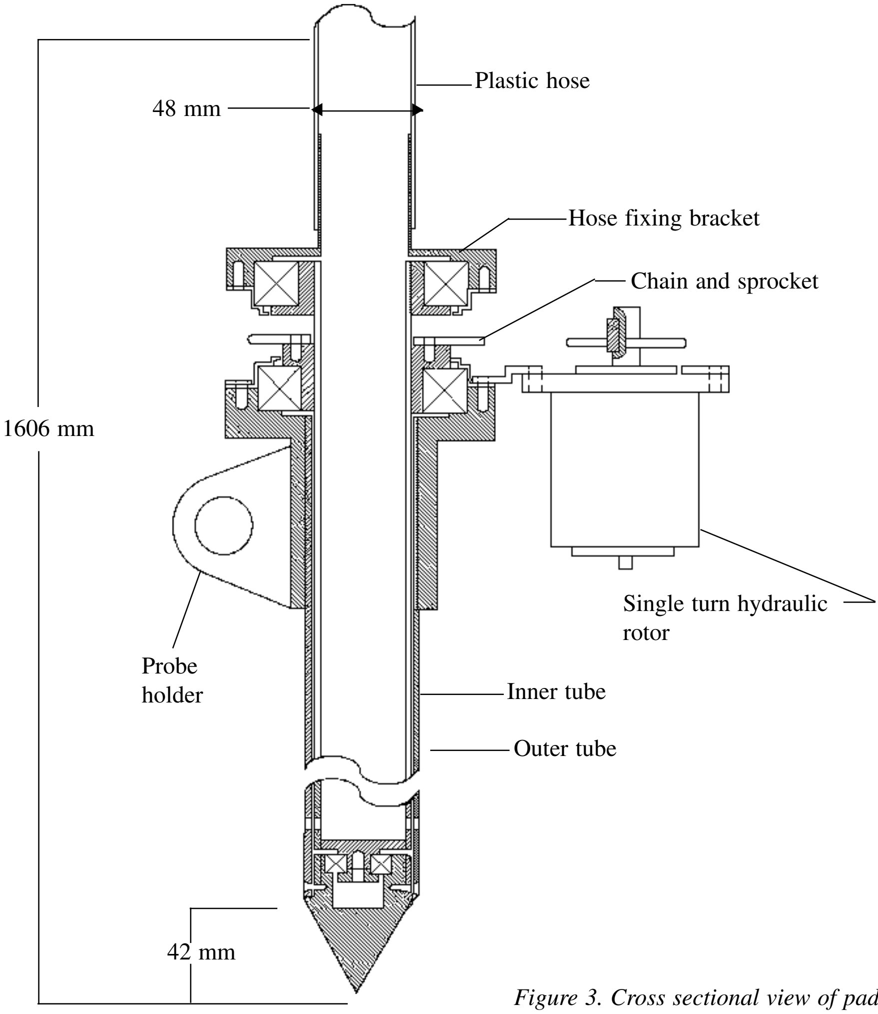

Figure 3. Cross sectional view of paddy probe

cause the air to flow from the bottom to the top opened end of the inner tube. The clearance between tube walls is made very close so that air suctioning through this gap when slotted holes misalign is very minimal. A long flexible plastic hose is connected to the top opened end of the inner tube to convey sucked paddy grain into a collection box. It is connected by a bracket specially designed to prevent warping of the hose.

The hydraulic probe transporter The functions of the probe transporter are to move the probe vertically, throughout the depth of the bulk paddy and then horizontally from one location to another. The probe transporter must also have structural strength to withstand high draft from the probe while inserting through the bulk paddy. In designing the probe transporter, several concepts were considered and the final design of the probe transporter as illustrated in *Figure 2* was chosen.

The probe transporter consists of two articulating arms of rectangular frame which carries a probe in the 'X' and 'Y' directions and also provides railing for a long vertical movement of the probe through the bulk paddy. The arm structure has geometrical dimensions in such a way that it could locate the probe at the centre and four corner positions in a truck compartment. The structure of transporter arm is made of lightweight hollow square beams with sufficient strength to withstand thrust of the probe while inserting into the bulk paddy. The advantage of lightweight structural design of the probe transporter is that it can facilitate a high speed automated bulk paddy sampling operation.

Two different capacity of 270° turn hydraulic rotors are used to provide an independent rotation of the probe transporter arm. The use of single turn rotor simplifies the design of transporter drive in which the rotor and the transporter arm shafts are coupled directly by a simple collar. The probe transporter is mounted on an 'A' frame with a height slightly above the bulk paddy level inside the truck.

A schematic drawing of hydraulic system to power the probe and the probe transporter is shown in *Figure 4.* The system is powered by a 3-hp hydraulic pump driven by a single phase ac motor. The hydraulic actuators of the probe and the probe transporter arms are controlled by energizing the respective electrical hydraulic valves which links through a cable to a push button panel or a dedicated control instrument. In this experiment all actuators, except a rotor for twisting the probe inner tube, were installed with flow control valves. This is to facilitate travelling speed of the probe and transporter arm be adjusted to obtain optimum sampling time of the bulk paddy. As a safety measure, a 12-volt dc supply was used to power the electrically operated hydraulic control valves.

Design of a motorised paddy mixer

The paddy sample taken from the bulk paddy needs to be mixed uniformly and then reduced in size to produce a required working sample for rapid and accurate quality assessment. A motorised mixer was designed and constructed as shown in *Plate 2*. The mixer is made of 'Y' shaped cylindrical metal container with flapper chute at the bottom and powered by 1/8 hp motor through a chain sprocket and a gear box reduction drives. A spring loaded valve is installed at the lower end of the chute

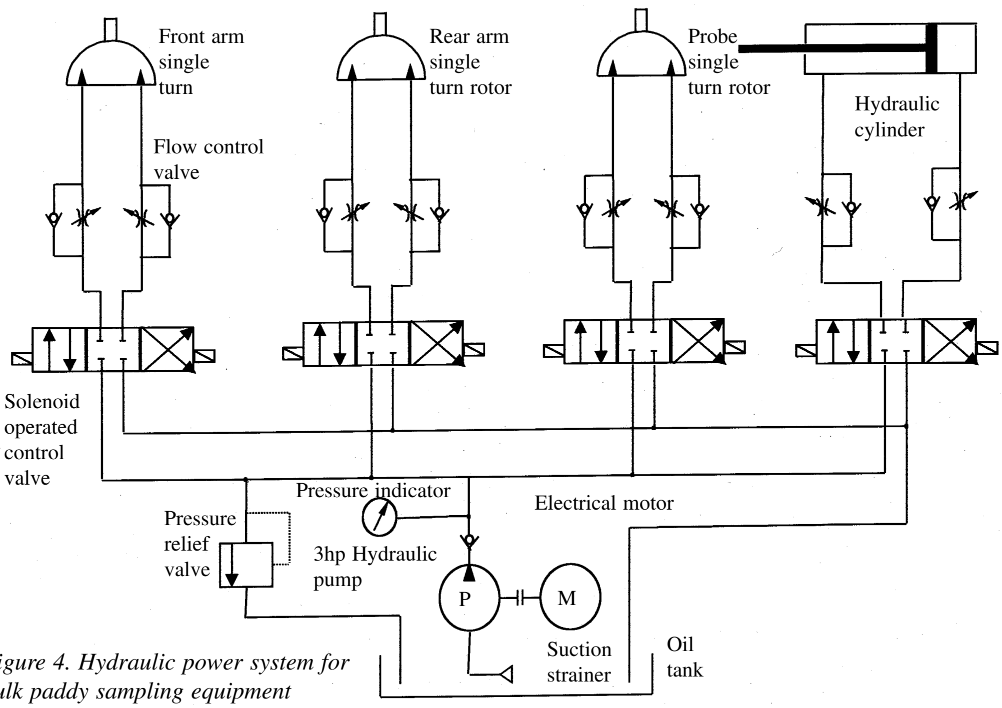

Figure 4. Hydraulic power system for bulk paddy sampling equipment

which could be tilted to release a specific amount of sampled paddy into a can. The chute could be opened by loosing a wing nut so that paddy sample inside the collection box could be poured quickly into the 'Y' shaped container of the mixer. The mixer rotates along its spindle shaft which is laid through the centroid of the 'Y' shaped cylinder to minimize wobbling. The operation of the motor is controlled by a timer relay circuit of which mixing time of the sample paddy could be set manually.

In addition the motor is also wired using push buttons for an anticlockwise and clockwise turning option to bring the chute at either to a top or down position after a completion of paddy mixing operation. The mixer rotates when the start push button is pressed, and stops automatically at the end of pre-set mixing time. Then the chute is brought to a lower position and the sample is released slowly into a can. The excess paddy samples can be removed quickly by opening the chute of the mixer. The chute is aligned to a top position to pour new paddy sample inside a mixer.

Designing and testing of a microprocessor controller for bulk paddy sampling equipment automation

The main considerations to automate operation of the bulk paddy sampling equipment are to have fast, uniform and consistent process of paddy sampling which are lacking when carried out manually. By means of automation, the positioning, pushing and lifting of the probe from one location to another over the bulk paddy can be performed in a sequence at relatively fast speed and avoiding mishap on operating the equipment. In addition the sampling process can be monitored in a comfortable room avoiding operator fatigue from long hours of working under dusty and hot temperature environment. Therefore, the overall time for the bulk paddy sampling operation on many trucks arrived at the rice mill can be reduced substantially.

To automate the bulk paddy sampling operation, the controller functions as follows :

i. The controller activates and monitors the transporter arms to locate the probe at the desired sampling locations.

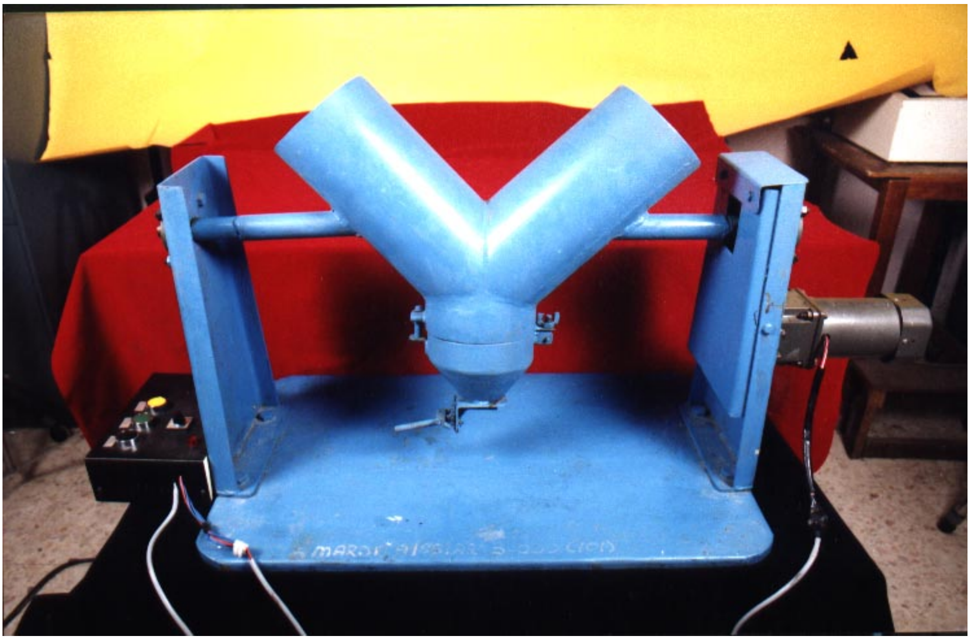

Plate 2. Paddy motorised mixer

ii. At the sampling location, the controller activates the probe to the lowest depth in the bulk paddy. The slotted holes of the inner and outer tubes are aligned for a short duration to collect paddy samples and then the slotted holes are misaligned to block the grains by controlling the single turn rotor.
iii. The probe is raised to the highest position slightly above the surface of the bulk paddy. A pneumatic pump is activated to convey paddy sample from the probe to a collection box.

The controller repeats step (i) to (iii) for the other locations and after completion of the sampling process, the transporter arms is activated to a home position.

Automation of the bulk paddy sampling equipment operation requires a customized standalone microcomputer/ microprocessor link with appropriate sensors for monitoring sampling locations and depth of the probe over the bulk paddy. A microprocessor base relay controller which controls the switching of respective hydraulic solenoid valves and pneumatic motor by monitoring limit switches and analogue signal output sensors of the bulk paddy equipment were designed and tested (Anon. 1988, 1989; Bishop 1981). The design of the controller is shown in *Figure 5* consisting of microprocessor, the analogue to digital converter, voltage reference, relay driver and power supply electronic circuit subsystems.

The microprocessor subsystem is made of a 6802 Motorola microprocessor with built-in 128 bytes internal RAM, interfaced with one megabyte EPROM and a Peripheral Interface Adapter (PIA). The subsystem is wired by a NE555 timer power on reset circuit for initializing the microprocessor and PIA during power on. The EPROM device contains machine code program instructions to implement equipment control strategy for the bulk paddy sampling operation. A programmable four input channel UP7002 NEC integrating analogue to digital converter (ADC) circuit is developed for measuring voltage outputs from the potentiometers which monitors the sampling location of the probe. The ADC address, data and control bus are directly connected to a processor and it is programmed to read eight bit digital value conversion from two of its input channels which are connected to potentiometer output voltage terminals by twisted pair wires. The PIA is programmed by configuring its input/ output peripheral pins as three inputs and 15 outputs. The three input pins are for the processor to read signals from the start push button, upper and lower stop limit switches of the sampling equipment. The other 15 output pins through a Darlington transistor switching relay drive circuit are for on/off control of hydraulic actuators and pneumatic pump.

The voltage reference subsystem produces one stable voltage output for the ADC voltage reference terminals and another two output voltages for biasing the low cost potentiometer sensors. Each potentiometer shaft couples directly to the transporter shaft so that the potentiometer produces a linear output voltages in proportion with the respective rotational angles of the transport's arm which is read by a processor to determine a probe sampling locations. The potentiometers are wired wound type with 270 degree electrical rotation, and they are selected because of low cost and simplicity which do not require amplifiers circuitry. *Plate 3* shows a functional PCB design of a microprocessor controller excluding the power supply and the relay driver subsystems.

A program for the microcomputer subsystem to control operation of the bulk paddy sampling equipment was written and compiled by using 6802 microprocessor cross assembler software. The program flow chart is illustrated in *Figure 6*. It consists of PIAINIT subprogram, PROBEHOME and PROBE subroutine. The PIAINIT subprogram is to configure or initialize the PIA into two separate eight peripheral data pins as input pins at the 'A' side and output

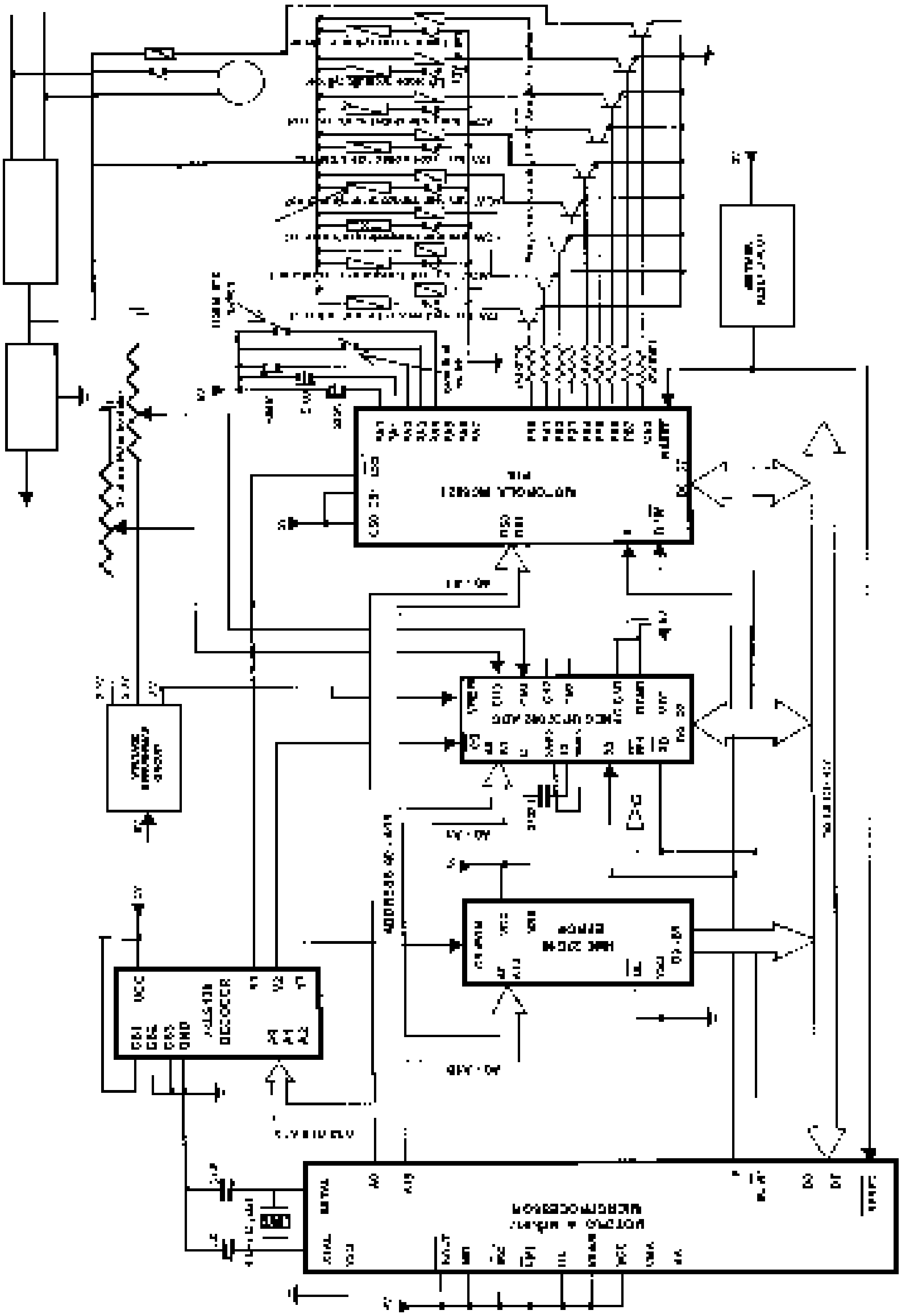

Figure 5. Schematic diagram of a microprocessor base controller instrument

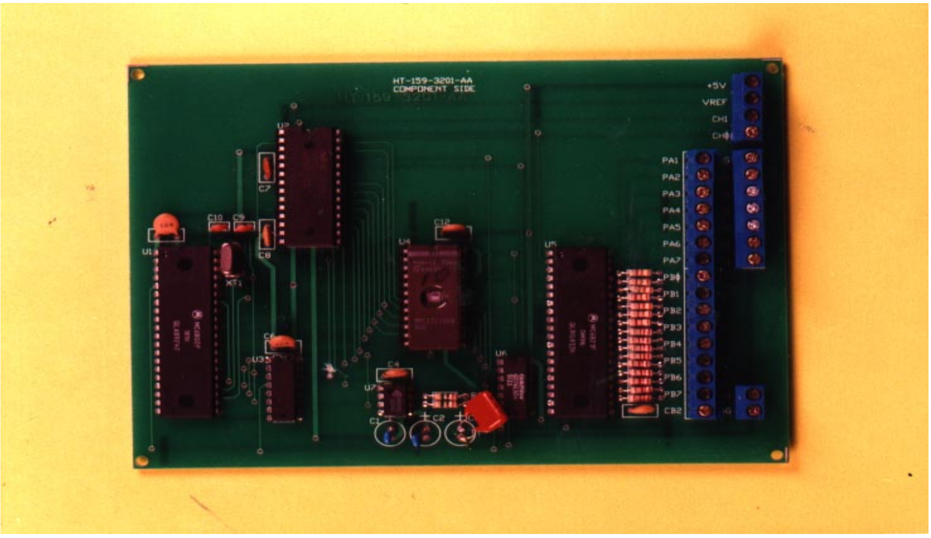

Plate 3. 6802 Motorola microprocessor controller module

pins at the ‘B’ side. The ‘A’ input and ‘B’ output side pins of the PIA are interfaced with limit or push button switches and relays of the hydraulic solenoid valves respectively. Therefore under a program control, specified data bits written by the microprocessor to the PIA eight data lines is produced on the output pins, and similarly signals from limit switches or push button appeared at the input pins can be read by the microprocessor through the data lines. Once the PIA is initialised, the rest of the program can directly communicate input signals from switches or deliver output signals on respective relays which operate the hydraulic actuators.

The purpose of the PROBEHOME subroutine is to bring the probe transporter arms to a home position with the probe at the highest position away from the bulk paddy truck. Immediately after the microprocessor system power is up or reset, the PROBEHOME subroutine responds when initial press at the start push button is made. The subroutine is designed to ensure that in case of power supply failure or emergency shut off, the operation of the bulk paddy sampling can be restarted. The actual bulk paddy sampling program responds only when a start push button is pressed for a second time after a short time delay. The program contains instructions for the equipment to perform sampling operations in sequence at the centre and four corners locations of the bulk paddy. It is made up of five loop instructions called PROBE subroutine. The instructions in each loop read digital values of both potentiometers which represent the angular position of the transporter arms and these values are compared against the set sampling location values stored in RAM of the microprocessor system. Once reading of respective potentiometer equals to the set value, the corresponding probe transporter arm is stopped by sending output signal to deenergise its hydraulic rotor solenoid. The loop ensures that both arms are stopped before calling the PROBE subroutine.

The PROBE subroutine is called upon for collection and conveying of sample paddy by the probe and pneumatic pump respectively. The subroutine consists of instructions, first to activate a hydraulic cylinder pushing the probe into the bulk paddy and while it is sinking, the program continuously looks for an output voltage from the lower limit switch. When the probe reaches the lowest set position, the lower limit switch outputs a signal to instruct the

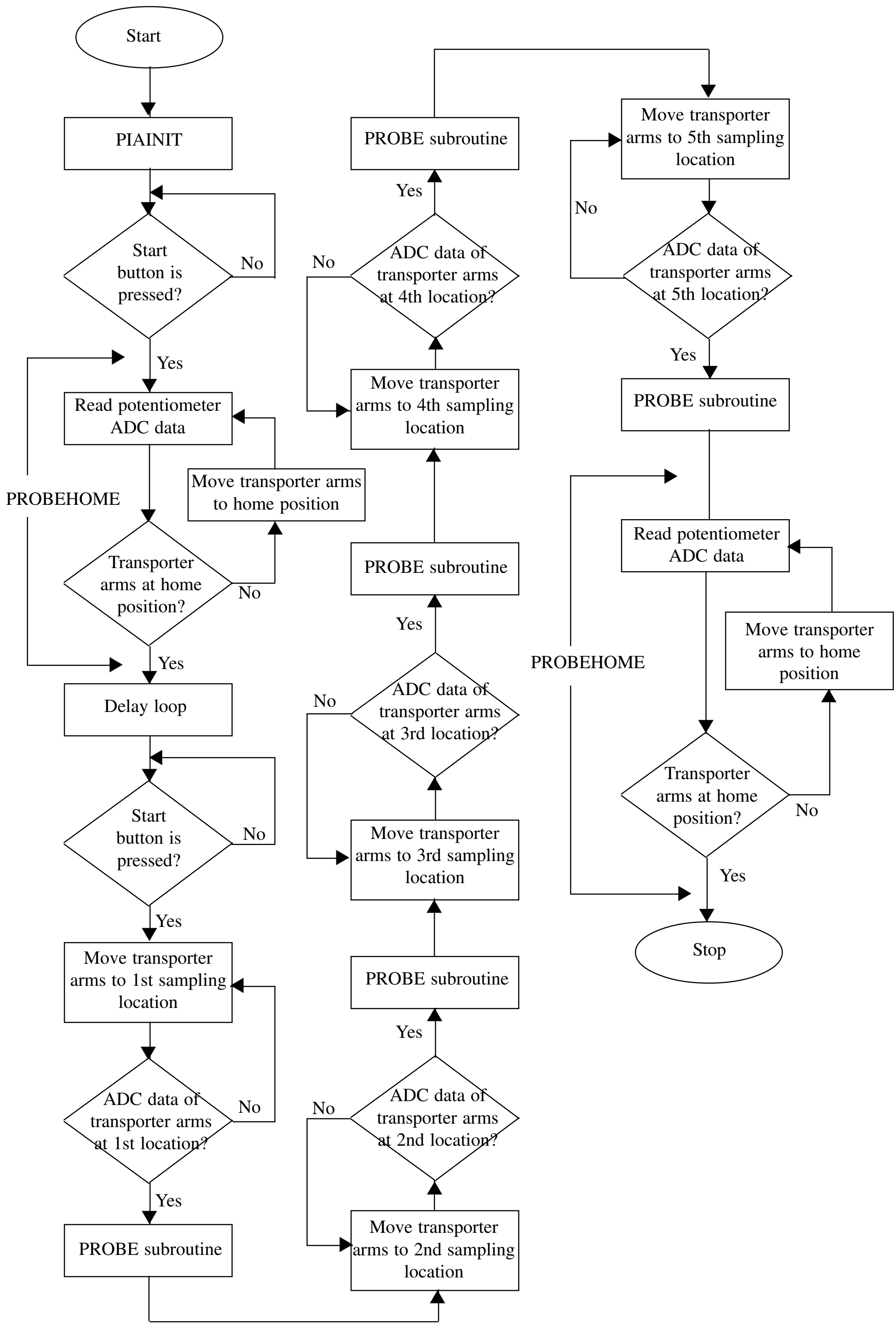

Figure 6. Program flow chart of bulk paddy sampling equipment automation

program to stop further sinking of the probe. Further instructions in the subroutine align the inner and outer tube slotted holes of the probe for a few seconds to collect the sample paddy. Then pneumatic pump is activated for conveying paddy sample into a collection box. Finally the subroutine gives instructions to lift the probe and then stop at the highest position which is acknowledged by an upper limit switch voltage signal. At the end of the fifth bulk paddy sampling location loop, the program calls PROBEHOME subroutine to bring the transporter arms to a home position.

Tests were carried out on the microprocessor hardware and software, analogue to digital, voltage reference circuit, potentiometer measurement and relay driver circuit subsystems. For the microprocessor subsystem, several short test programs on the microprocessor alongside with each programmable device were carried out until it worked successfully. The test programs were the processor communication with the PIA and the analogue to digital converter by writing short machine code programs in the EPROM memory. In case of testing communication of the processor with the PIA, a short program was run on the processor to read signal from switches connected with 'A' side of the PIA input pins, and once it was detected a known byte code signal was written on the 'B' side output pins. Test on the processor linking with the ADC was done by running a short program converting a known input voltage signals on the input channels and then display the digital value conversions on the 'B' side of the PIA output pins. The digital values in the test were verified with logic signals using a logic probe tester. The operation of the relay drivers was tested by sending output signal from 'B' side of the PIA to the relay driver base input transistors and then observed the closure of the relay contact points. The accuracy and stability of the voltage outputs of the voltage reference circuits are essential for a proper digital conversion or resolution of the ADC and the potentiometer voltage biasing. The voltage reference was calibrated to output accurate digital conversion values of the ADC while applying a known accurate input voltage at its input channels using a YOKOGAWA calibrator. The potentiometers were also biased accurately and the test result showed a good linear relationship of output signal voltages versus shaft angle positions of the potentiometer.

In the latter stage, the designing and testing of an assembly language program alongside with the microprocessor system hardware for controlling operation of the bulk paddy sampling equipment as described earlier were carried out. The program was tested with several relays, limit switches and potentiometers attached to the respective input or output pins of the PIA and ADC of the microprocessor system. In the tests, the potentiometers and limit switches were manually operated simulating the control strategy of the bulk sampling equipment and simultaneously observed the response of the program to actuate respective relay contacts.

Results and discussion

The bulk paddy sampling equipment was tested in a laboratory using a freshly combine harvested paddy of 20% moisture content obtained from a farmer in Negeri Sembilan. The paddy was poured inside a container to about the depth of the bulk paddy inside the truck. The bulk paddy sampling equipment was tested at the centre and the four extreme corners similar to the sampling locations of the bulk paddy in the truck. The results of the functional test showed that the bulk paddy sampling equipment worked satisfactorily. The deep probe penetrated smoothly throughout the depth of bulk paddy without buckling. The inner tube rotated freely against the outer tube of the probe and the alignment and nonalignment of the slotted holes of the tubes were quite fast. The probe collected the paddy sample by aligning the slotted holes of the inner tube against the outer tube for a few seconds then the sample paddy conveyed effectively over a long hose to a collection box by a pneumatic suction. The front and rear arms of the transport mechanism were able to articulate in clockwise and anticlockwise turns for locating the probe at the centre and four extreme corners. The maximum probe depth inside the bulk paddy was 1 200 cm and an average weight of sample paddy collection was 500 g. A total amount of 2.5 kg of sample paddy was collected for all five sampling locations of the bulk paddy.

After the equipment had undergone several tests, the probe transporter structure and brackets were found sufficiently strong to push the probe throughout the bulk paddy. The brackets mounted on the ‘A’ frame which supported the transporter were tested for strength by applying the brackets to a maximum bending stress. This was accomplished by pushing the probe over the bulk paddy while the transporter arms were straightened. The sampling time of using this equipment depends on the operator's skill in manoeuvring the transporter to locate the probe at desired sampling spots and speed of penetration or retraction of the probe over the bulk paddy. To optimize the sampling time, the penetration of the probe throughout the bulk paddy was set at a low speed to avoid any possible buckling, while the retraction of the probe was set at a much higher speed. The articulation speed of transporter arms was adjusted by trial and error until the arms gave minimal overshoot when stopped.

The performance of the equipment was tested manually by pressing in sequence the buttons of control box which activate hydraulic actuator, and the time to sample the bulk paddy was recorded. The time to sample bulk paddy on one location was about 20 seconds. It was measured from inserting the probe into the bulk paddy, align and then non align its slotted holes, lift it to a top position and convey the paddy samples to a collection box. The time taken for sampling paddy at all five locations over the bulk paddy was between two and three minutes depending on the operator skill. There is a tendency for the probe to bend when the transporter arms are rotated while the probe is still inside the bulk paddy. Therefore it is necessary for the operator to operate the equipment with caution to avoid damaging the probe. However, it is envisaged that the problem can be avoided once the probe transporter is manoeuvred automatically by an appropriate control instrument.

The design of drive mechanism for the transporter arms was simplified by using a single turn rotor. However from a series of tests, it was observed that the swing of the transporter arms tended to overshoot when trying to stop the probe at the sampling location due to lack of damping of the hydraulic rotors. The use of existing direct shaft drive was suitable for low speed but unsuitable for fast speed of bulk paddy sampling operations. The speed of the probe transporter could be improved by driving the shafts with a continuous turn hydraulic rotor coupled with a high reducer ratio spur worm gearbox which provide better torque and self braking. The transporter arms can be halted immediately and hence the probe can be positioned at a precise location over the bulk paddy.

The microprocessor based controller module for application of the bulk paddy sampling automation were designed and tested in the instrumentation laboratory. The results from the tests show that the microprocessor based controller worked well. The program codes written and compiled in assembly language for control strategy of the bulk sampling equipment were executed successfully by the microprocessor hardware. Throughout this experiment, we finally established the hardware and software design requirements for the 6802 Motorola microprocessor base controller. Although the controller was designed specially to control operation of the bulk paddy sampling equipment, the module could also apply to other machine control application by writing different program codes in the EPROM device.

Further works on the bulk paddy sampling equipment are still required before it can be fully tested for automation. These include modification on the transport arm drive mechanism for ease of manoeuvring and accurate positioning of the probe at the sampling locations, improvement of existing hydraulic lines layout of the equipment for higher hydraulic efficiency and neatness and the fabrication of control instrument. Calibration of potentiometer voltage outputs values against desired sampling locations need to be carried out and their values stored in the microprocessor memory.

The tests on motorised mixer were conducted in the postharvest laboratory in MARDI Alor Setar. The motorised mixer functioned satisfactorily and it rotated at 140 rpm. Various sizes of paddy samples extracted from this machine with variable time for mixing were analysed. After a series of tests, it was found that a mixing time of 99 seconds and extraction of 10 g paddy were sufficient for the preparation of paddy samples.

Conclusion

A paddy bulk sampling equipment was designed and fabricated for sampling of bulk paddy in trucks. The equipment worked satisfactorily when operated manually. The hardware and software requirements for the 6802 Motorola microprocessor based module to function as a stand alone controller of the bulk paddy sampling equipment operations were successfully designed. In order to automate the operation of the bulk paddy sampler equipment, design improvements on the probe transporter drive, hydraulic layout and further development on controller instrument are required. The motorised paddy mixer for preparation of uniform and workable size paddy sample for analysis was also successfully designed and locally fabricated.

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