Knowledgebase for Maintenance of Modern Irrigation Systems

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ABSTRACT

Egypt has limited water supplies accompanied by increasing water demand. Proper management of irrigation water consists of determining when to irrigate, the amount of water to apply and the operation and maintenance of irrigation systems. In this study, a knowledgebase system was developed to propose maintenance programs for the major components of modern irrigation systems (Sprinkler & Trickle).The knowledgebase has three modules; preparation for off-season; before system operation and routine maintenance after operation. The knowledgebase was verified and tested and proved to be a useful maintenance advisor for modern irrigation systems and a good training tool.

INTRODUCTION

Water has become a scarce resource throughout the world. Arid areas like Egypt need more emphasis on proper using of modern irrigation systems.

Carefully developed and diligently implemented maintenance program will normally extend the life, improve performance and reduce the operating cost of modern irrigation systems (Nakayama and Bucks, 1986). It will also reduce unplanned system shutdown, which interrupt irrigation schedules. This is especially important with trickle irrigated crops since they commonly have high market value and/or limited root zones for storing water.

Hassan, 1998 stated that, there are two kinds of maintenance; preventive and after-the-fact, the former saves money and the later costs money. Preventive maintenance practices include water filtration, field inspection, pipeline flushing, and chemical water treatment. Water filtration and field inspection are absolutely essential. Flushing laterals and pipelines can help to minimize sediment build-up, and chemical water treatment can improve the long term performance of the trickle irrigation system.

The preventive maintenance requirements of major components of modern irrigation systems are discussed in details by: Pair et al., 1975; Rolland, 1982; Jensen, 1983; Nakayama and Bucks, 1986; Keller and Bliesner, 1990; and Hassan, 1998.

El-Yazal et al., 2005, found that, it's important to have operation and maintenance program for the control head unit in drip system. There is also

a strong relation between the operating factors and maintenance operation that improve the efficiencies of control head unit.

Knowledge systems capture the expertise and reasoning abilities of experts in a field or domain. They reproduce the problem-solving abilities of the experts based on knowledge that has been coded into the system (Carrico et al., 1989).

This work concentrate on the first three points of preventive maintenance: water filtration, field inspection, and pipeline flushing. The information related to these points was gathered and coded to build a knowledgebase that propose maintenance programs for the major components of modern irrigation systems. The knowledgebase has three modules; before system installation; before beginning of operation; and routine maintenance when system operation begins.

DEVELOPMENT PROCEDURE

Knowledgebase Expert Systems (KBES) provide institutional memory. The knowledge accumulated during years of field experience by extension and other agency crop experts is often poorly documented and tends to be lost when the individual retires. KBES are immortal, allowing preservation of valuable heuristic knowledge (Broner et al., 1992).

Identification:

The **M**odern Irrigation **S**ystems **M**aintenance **A**dvisor (**MISMA**) is a knowledgebase expert system that uses backward chaining rule-based inference to determine the maintenance program for the different components of modern irrigation systems. These components include; pump (centrifugal or vertical turbine), power unit (electric motor or internal combustion engine), filtration equipment (settling basin, media, screen, cartridge filters, and centrifugal sand separators), chemical injection equipment, flow meters, valves (pressure relief, on-off, pressure regulating, vacuum relief, flow regulation, and air relief valves), controller and sensors, pipelines and laterals, emitters, and sprinklers.

The author works as knowledge engineer (extracts knowledge from many resources, defines the main classes and their attributes, and builds the KBES) and works as the domain expert to evaluate it. The main source of information was the literature, bulletins, reports, and other publications. The knowledgebase was developed by the use of LEVEL5 OBJECT tool kit.

Conceptualization:

At this stage, the proposed maintenance programs for pump, power unit, filtration equipment, chemical injection equipment, flow meters, valves, controller and sensors, pipelines and laterals, emitters, and sprinklers were identified and divided into three modules (preparation for off irrigation season, preparation before irrigation season and routine maintenance during the irrigation season).

Formalization:

During this stage a decision table was build for the different maintenance programs proposed for each component of modern irrigation systems as follows:

Preparation for off-season	Preparation before season	During season
	1. Pump	
- Drain water from pump. - Remove suction lines. - Cover all bearings with lubricant. - Cover shaft and other exposed metal with protective lubricant. - Remove suction cover. - Check wear ring and impeller wear. - Clean debris from impeller and volute. - Remove packing gland and packing. - Check wear on shaft sleeve. - Repack pump. - Be sure liquid passages are not obstructed. - Loosen all belt drives. - Insert grease-proof paper between belts and pulley.	- Clean trash screen. - Check foot valve on suction line. - Install or check suction line (must be air tight). - Be sure all liquid passages are not obstructed. - Tighten packing gland to proper setting. - Change bearing oil and/or lubricate bearing with grease gun. - Adjust impeller of vertical turbine pumps. - Check static water level. - Start pump and check noise, vibration, leakage, flow rate, pressure, and bearing temperature after one hour of operation. - Check drawdown.	- At least every 2 days check: noise vibration leakage bearing temperature flow rate and pressure trash screen pumping level - Lubricate pump as per manufacture's recommendations.
	2. Power Unit	
	2.1. Electric motor	

- Clean dust, debris and caked-on dirt and oil from motor. - Visually check motor windings insulation. - Lubricate all bearings. - Cover motor properly. - Lock service cabinet in 'off' position. - Cover exposed service cabinets.	- Change motor bearing oil and/or lubricate bearings. - Change oil in reduced voltage starters. - Clean debris from motor. - Check ventilation vents. - Check safety shields. - Check overhead service lines. - Replace conductors having fried, cracked, or worn insulation. - Be sure all conduit or cables are good. - Test coils and heaters. - Clean all magnet surfaces. - Check the interior of service cabinet. - Check and tighten all electrical connection. - Be sure all contact points are free of corrosion. - Operate all moving parts by hands before applying power.	- At least every 2 days check: noise vibration winding temperature bearing temperature that ventilation screens are clean - Lubricate as per manufacturer's recommendations. - Check electrical demand of motor.
2.2. Internal combustion engine		
- Run engine to worm up oil. - Stop engine and drain oil. - Replace drain plug. - Refill crankcase with high grade engine oil. - Run engine slowly for 2 minutes. - Stop engine and remove all spark plugs. - Pour 60 ml of engine oil into each spark plug hole.	- Remove sealing tapes from openings. - Open fuel tank valve. - Shut water drain cocks and add coolant. - Tighten oil drain plug. - Replace oil filter and add correct amount of engine oil. - Remove spark plugs and spray cylinder walls with light engine oil. - Replace spark plugs. - Crank engine by hands.	- At least every 2 days check engine: temperature oil pressure fuel consumption vibration noise - Change oil and lubricate as per manufacturer's recommendations

- With engine switch off, crank engine to distribute oil. - Replace spark plugs. - Drain oil. - Drain cooling system. - Drain all fuel. - Lubricate all accessories. - Seal all openings. - Check oil filler cap, gas tank and radiator cap. - Spray all accessories and electrical equipment with suitable insulating compound. - Insert grease-proof paper under the 'v' belt pulley. - Remove battery and store fully charged. - If engine outside, cover with a water proof covering.	- Fill fuel tank. - Lubricate engine accessories. - If a distributor is used, clean inside and outside of cap. - Inspect cap and rotor for cracks. - Check all terminals and electrical connections. - Run engine slowly for 2 minutes, check oil pressure. - Check oil level in crankcase.	
	3. Filtration equipments	
- Flush and drain filtration equipments. - Drain and clean settling basin. - Inspect interior components of media filters, centrifugal separators, and screen filters. - Clean filter manually with natural bristle brush if necessary. - Check condition of seals, gaskets, and valve seats. - Service valves. - Disconnect electrical conductors from power	- Be sure all electrical connections are clean and tight. - Check all electrical contacts. - Verify that filtration equipment, including automatic control system, operate properly. - Inspect the media for proper level and cleanliness. - Check backwash restrictor valve for proper adjustment. - Be sure screen is not torn, if so replace. - Assure 'O' ring rubber	- At least every other day: Be sure that filtration equipment and associated automatic controls are operating properly. Check the need for manual flushing (if pressure difference reach 0.3445 bar/5psi maximum). - At least monthly : Inspect media for proper level and cleanliness. Check backwash restrictor valve adjustment.

source. - Check electrical conductors.		seals are properly positioned. - 'O' ring may be lubricated with non-petroleum oil such as vegetable oil or liquid soap to facilitate assembling.	Inspect all couplings and connections for leaks. Inspect all components of automatic control system. - Service valves as per manufacturer's recommendations. - Once a year clean settling basin either mechanically or by water flushing and remove sediments. (depending on the amount of sediments several times per year may be necessary)
		4. Chemical injection equipment.	
		- Make sure all liquid passages are free of obstructions. - Check oil levels in motor, pump, and gear reducers. - Check motor, pump, and gear reducers for noise, vibration, and bearing temperature. - Check for leaks. - Verify injection rate.	- Every 24 to 48 hours of operation: Visually inspect hoses, valves, pump, motor, tank, and other injection equipment. Check for leaks. Check oil levels in motor, pump, and gear reducers. Check motor and pump for noise, vibration, and bearing temperature. - Lubricate motor, pump, and gear reducers as per manufacturer's recommendations. - Complete injection with time that remain to run clean water through the system to insure complete flushing of fertilizer from all piping work. - Flush pumps and tank after every use.

		- Periodically clean filters, strainers, and screens.
5. Flow meters		
- Clean the exterior and interior of the meter. - Check for bent impeller blades, worn blade and orifice edges, pitted or eroded meter sections. - Check bearing and shaft wear in rotating meters. - Check for damaged flow straighteners. - Remove batteries from ultrasonic meters and store fully charged. - Store meter in clean, dry place. - Lubricate flow meters.	- Clean the meter. - Repair leaks in gaskets and fittings of meter and pressure sensing equipment. - Check electrical conductors. - Check electrical connections. - Verify flow meter accuracy.	- Every time the flow meter is used inspect the meter for: Missing hardware Loose screws Fogged or broken register lens Leakage Other signs of wear - Lubricate rotating meter as per manufacturer's recommendations. - Monitor pressure drop across meter and clean filters, strainers, and screens when needed.
6. Valves		
- Drain all valves. - Lubricate valves. - Clean valves. - Be sure valves are open.	- After disassembling, clean and inspect automatic diaphragm valves. - Inspect valve packing. - Verify that valves operate properly.	- Weekly, inspect valves for leakage and proper operation. - Lubricate valves as per manufacturer's recommendations.
7. Controllers & sensors		
- Clean controller and sensors. - Check controller panel seals. - Remove and store batteries. - Flush and drain hydraulic control conduits. - Disconnect field wires. - Check electrical conductors.	- Be sure all electrical connections are clean and tight. - Check electrical contacts. - Inspect all hydraulic and pneumatic control conduits for leaks. - Verify that all accessory equipment and sensors operate properly.	- Visually check all external components weekly. - Disconnect field wires during electrical storms. - Disconnect batteries when controller is to be out of service for one week or more.
8. Pipelines & laterals		

- Mark all leak locations during system operation. - Flush and drain mains, submains, and laterals at furthest locations. - Open all valves - Inspect pipes for corrosion.	- Remove animals, bird nests from pipelines. - Flush and drain mains, submains, and laterals. - Inspect pipes for leaks. - Assure air vents are free from blockage and are free to work properly. - Fill mainline slowly on start-up by closing pump discharge gate valve half way and open fully after mainline pressure rises to 20psi. This assure mainline is full and eliminate damage to pipe network by water hammer. - Poly hose should be positioned in center of plant row to avoid damage from tractors. - Check hose connection at submain and riser to avoid kinking or disconnection. - Ensure adequate snaking in row to avoid hose pulling out of fittings. 2 meters per 100 meters is good. Use no lubricant or glue on fittings. - Assure bubbler stake is firmly anchored in soil to maintain vertical position. - Be sure the supply tube from poly hose lateral is not kinked to ensure proper flow to bubbler.	- Flush mains, submains, and laterals as required, start with weekly flush. - Increase interval between flushing until dirt is noticed. - Open flush valve fully-flush until water is clear (water will be clear, followed by dirty water then turn clean again). Close valve fully. - Flush only one submain at a time. - Flush only 1 to 5 poly hose at once. A minimum flow velocity of 0.3 m/s is needed for flushing lateral line. Generally 2 minutes is adequate to flush hose. - Check for proper operating pressure in hose (adjust regulator if necessary). - If hose pressure is too low look for kinked cut or disconnected hose. Repair. - Do not tie-end of hose to stake. Hose must be free to move due to heat expansion/cold contraction. - Check inlet screen to bubbler periodically to avoid blockage. Clean as necessary.
9. Emission devices		
- Spot check emission device discharge and pressure.	- Visually check emission devices for clogging, damage, and other signs of deterioration. - Use only manufacturer's	- Monthly check discharge and pressure of critical emission devices (low spots and end of laterals). - Visually check emission

	recommended polyethylene hole-punch to emitter installation.	devices for clogging, damage, and other signs of deterioration at least once during the irrigation season.
10. Sprinklers		
		- watch for nozzle blockage. - Turn-off system, remove blocked nozzle, clear debris and replace. - If sprinkler fails to rotate, check for debris in arm drive, nozzle or broken parts. Contact your supplier. - Use no oil on impact sprinkler. Sprinklers are water lubricated. - Do not change sprinkler type or nozzle size without consulting supplier. - assure each sprinkler riser is vertical before and after start up.

Implementation:

After all the information about different maintenance program for each component of modern irrigation system is gathered in the above decision table, the main classes and their attributes were defined. Some of these classes represent the main components of modern irrigation systems: pump, power unit, filtration equipments, chemical injection equipments, flow meters, valves, controller and sensors, pipelines, emission devices and sprinklers. Then, this information was transformed into a group of rules, demons, and methods.

MISMA, the Modern Irrigation System Maintenance Advisor; uses backward-chaining inference strategy. It is controlled by an agenda consisting of three goals. You are asked a series of questions. Based on your answers, rules fire or fail in order to determine the goals. Demons build conclusions and show these conclusions at the end of the session.

Testing:

During the implementation process of MISMA the accuracy and the functionality of the knowledgebase were tested step by step. Then, the recommendations of the knowledgebase were compared by those of the domain expert and they completely agree with them.

RESULTS AND DISCUSSIONS

The Modern Irrigation Systems Maintenance Advisor 'MISMA" is a knowledgebase expert system that uses backward chaining rule-based inference to propose a maintenance program for the different components of modern irrigation systems (sprinkler & trickle). The maintenance program has three modules:

1. Preparation for off-irrigation season.
2. Preparation before starting the irrigation season.
3. Routine maintenance during the irrigation season.

When the user starts the knowledgebase 'MISMA', the title display appears (Fig. 1). From this display the user has to select the system (sprinkler or trickle) he wants to review the maintenance programs for their components. This display also contain a button named 'Explain' when clicked, another display appears that explain how the knowledgebase works and its purpose. After the user clicks the 'start sprinkler' button or the 'start trickle' button, the main input display appears (Fig. 2). This display contains a group of check boxes for the main components of the modern irrigation systems. It also has a radio button group for the three modules of maintenance programs. After the user selects the component and the required module, he has to click the 'ok' button. Then the conclusion display appears (Fig. 3) which contains the proposed maintenance program and the picture of that component. At this stage the user can restart another session or exit the knowledge base.

CONCLUSION

Although there is a cost associated with maintenance programs, it will maintain high system efficiencies, help reduce power costs, improve dependability of equipment, reduce operating costs and extended system

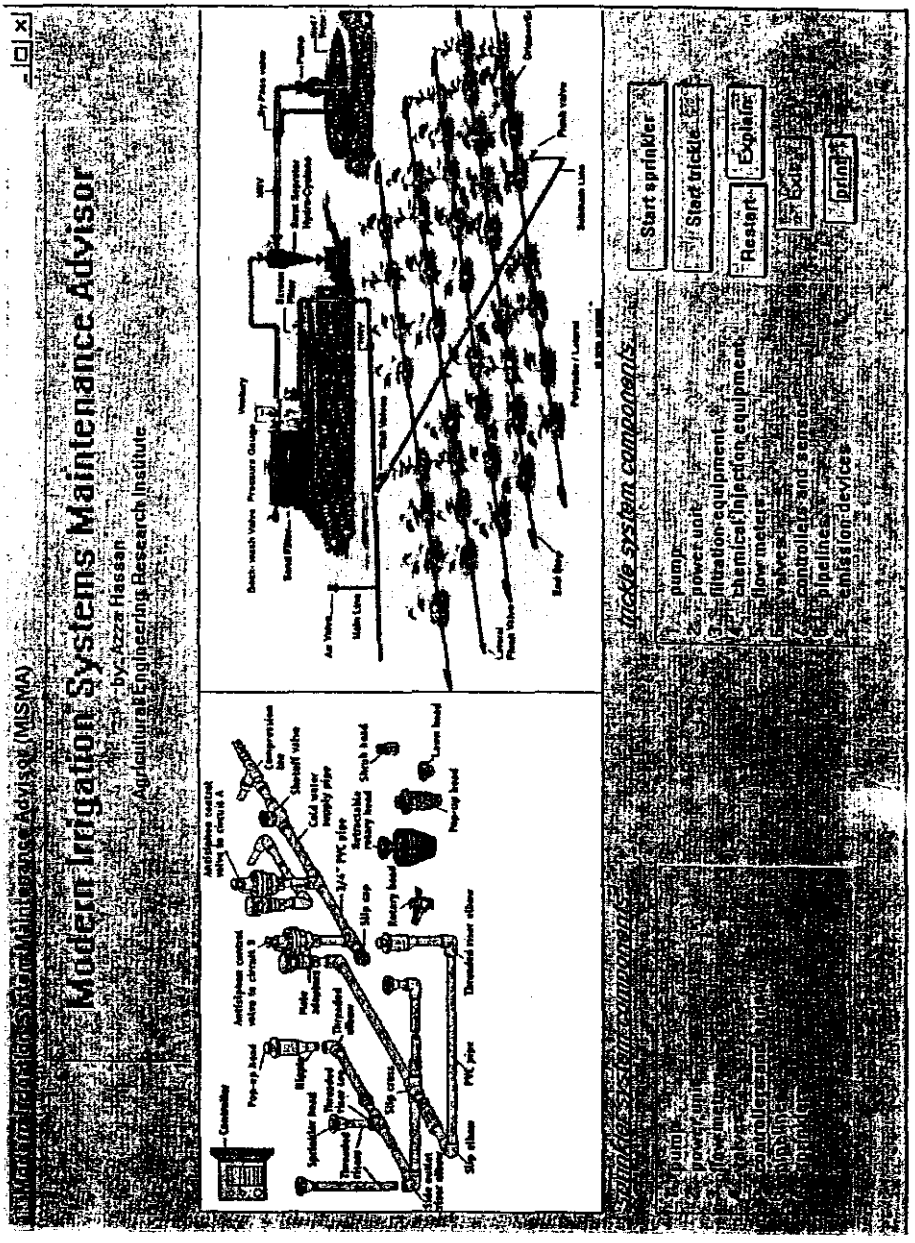

Fig.1 The title display

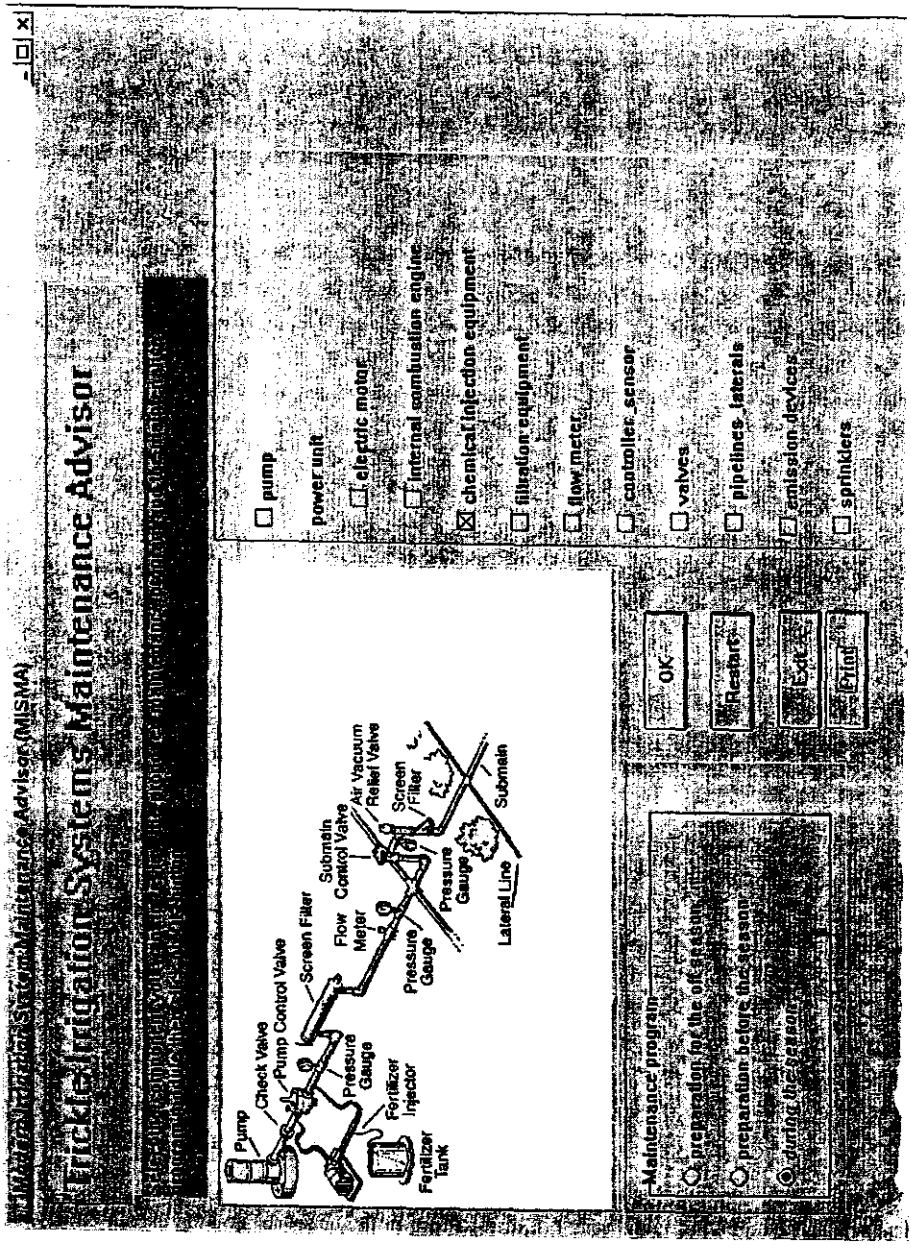

Fig.2 The main input display.

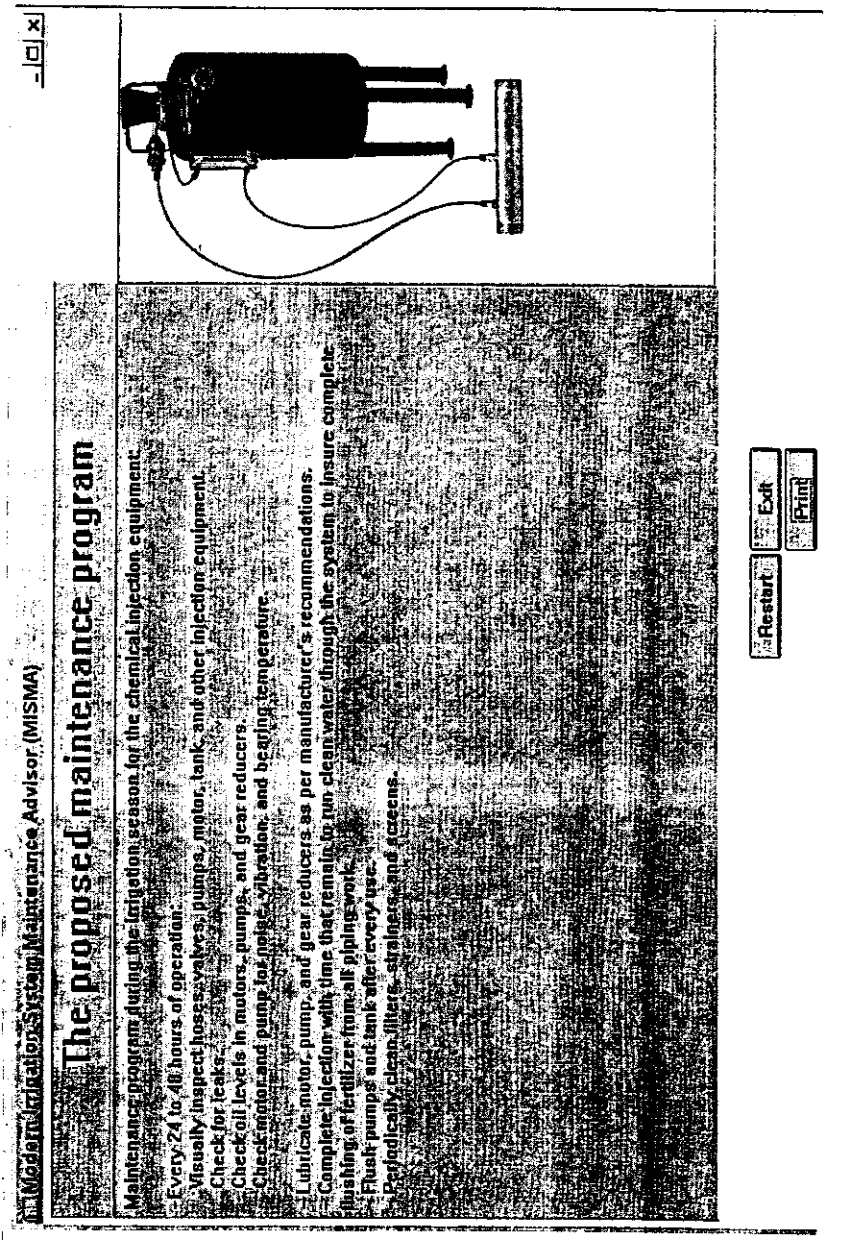

Fig.3 The conclusion display

life. Knowledge base expert system has a great advantage of gathering multiple expertises. The expert system is available all the time and it didn't get tried. The standard method was used to develop this maintenance advisor. The knowledge base was tested step by step during the development process. It is also checked after the completion by the domain expert. MISMA proved to be a good maintenance advisor. It could also be used as a training tool for different maintenance program. Nevertheless, the best developed software will need maintenance (modifying existing operational software while leaving its primary function intact). Finally, we recommend maintenance of any knowledge systems to make these systems more effective for the user and to add new information as it becomes available.

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الملخص العربى
قاعدة معلومات لصيانة نظم الرى الحديث

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باحث معهد بحوث الهندسة الزراعية

مع الزيادة المطردة فى عدد السكان بمصر ومواردنا المحدودة من المياة يتحتم علينا ترشيداستخدام مياة الرى بالادارة الجيدة لنظم الرى والتى تشمل على تحديد كمية مياه الرى ومواعيد اضافتها وأيضا صيانة تلك النظم. تعتبر الصيانة الكاملة والدورية من العوامل الاساسية لنجاح نظم الرى الحديثة حيث أن الصيانة المناسبة تطيل عمر نظام الرى وتحسن كفاءتة وتقلل تكاليف التشغيل. كما أن تطبيق برامج الصيانة يقلل احتمالات توقف نظام الرى عن العمل أثناء فترات التشغيل وخاصة بالنسبة للمحاصيل التى تروى بالتنقيط ولها قيمة اقتصادية عالية وعمق محدود للجذور. لذا كان الهدف من هذا البحث هو بناء قاعدة معلومات لصيانة أجزاء شبكات الرى الحديثة (رش- تنقيط) والتى تشتمل على: المضخة, وحدة الطاقة(الموتور او آلة الأحتراق الداخلى), الفلاتر, السمادات, عدادات قياس التصرف, الصمامات, وسائل التحكم والأستشعار, خطوط الأنابيب, النقطات, الرشاشات. وقاعدة المعلومات تقترح ثلاثة برامج صيانة مختلفة لكل جزء: برنامج فى نهاية موسم الرى, وبرنامج قبل موسم الرى, وبرنامج دورى فى أثناء موسم الرى. كان المصدر الرئيسى للمعلومات هو الأبحاث والنشرات والكتب. واستخدم LEVEL5 OBJECT كوسيلة لبناء قاعدة المعلومات. وتم اختبار قاعدة المعلومات MISMA وأثبتت كفاءتها كنظام معلوماتى يقترح برامج الصيانة المختلفة لكل جزء من مكونات شبكات الرى بالرش والتنقيط. كما انه يمكن استخدامها كوسيلة للتدريب على برامج الصيانة المختلفة سواء للطلبة أو المهندسين أو لملاك الأراضى الجديدة. ومع ذلك, نوصى بالصيانة المستمرة لاى نظام معلوماتى باضافة اى معلومات جديدة أمكن التوصل اليها أو تحسين البرنامج ليكون أكثر فاعلية للمستخدم.