

قُلْ أَرَأَيْتُمْ إِنْ أَصْبَحَ مَاؤُكُمْ غَوْرًا فَمَنْ يَأْتِيكُمْ بِمَاءٍ مَّعِينٍ))
((الملك: 30)

**Say (O Muhammad Peace Be Upon Him):“Tell me! If
(all) your water was to think away, who then can
supply you with flowing spring water?”
(AL-Mulk: 30)**

DEDICATION ...

**To my beloved and
sole smart daughter
“Muzan”**

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LIST OF SYMBOLS AND ABBREVIATIONS

Admin	Administration
BTU	British thermal unit
Disch.	Discharge
E	annual energy consumption
effic.	Efficiency
edu.	education
elect.	electrical
eng.	Engine
Fig	figure
Furr.	Furrow
F-belt	flat belt
Fed.	feddans
Galv.	Galvanized
gpm	gallon per minute
Hp	horse power
K_E	annual energy
K_e	energy cost
Kw	kilowatt
Kwh	kilowatt hour
L / s	liter per second
L / hr	liter per hour
m	meter
m^3 / s	meter cube per second
mm	millimeter
m^3 / hr	meter cube per hour
Mot.	motor
No.	number

rpm	revolution per minute
rec.	recommended
SPSS	statistical packages of social sciences
SSH	suction static head
S.	suction
Shall.	shallow
TDH	total dynamic head
V	fluid speed
Veg.	vegetables

ABSTRACT

This study was conducted on centrifugal pump-irrigated small private farms in Hasahiesa locality which distributed around the West Bank of the Blue Nile. The ultimate objectives of the study were to evaluate the performance of pumping plants of these farms in terms of pump efficiency, pump adequacy, overall efficiency and the net positive suction head available by each system besides comparing the actual operating conditions of the pumps in particular and the pumping plants in general with the equivalent rated and recommended ones. In addition to development of a computer model to link between the different input and output parameters and hence achieving the calculations associated with such evaluation process besides forming a comprehensive picture of performance that enables the evaluator predicting the effects of the changes in the pumping conditions. The pumping plants were provided with pumps completely of Indian make, powered either by electric motors or diesel-fueled engines and draw water either from the river or shallow wells. These pumping plants were using to irrigate farms with areas ranging between 2 feddans and 40 feddans. 36 units were randomly selected as a sample survey to represent the total population of 806 pumping plants during the growing season 2006-2007.

The study relied upon primary data collected via observation and questionnaire besides direct measurements. Then the subsequent relevant calculations were conducted to obtain the ultimate evaluation parameters mentioned above. In addition, a statistical analysis was made upon the obtained data using the SPSS technique. And hence, the results were explained and justified and the impact of the factors affect them were studied. The studied pumps were classified into seven categories according to their mark as follows; Saraf, Cuma, Lusab, Marshal, Atlas, Alfa and Anil. The main actual characteristics of each of these types which included; discharge, total dynamic head, pump speed, No. of v-belts and efficiency were measured and / or calculated and statistically analyzed using t-test to compare them with rated equivalent ones recommended by their manufacturers. Finally, the pumping plants actual operating conditions were measured and / or recorded and / or calculated. These included; the power of the used mover, the net positive suction head imposed by the system, suction

pipe size and the overall efficiency. These factors were statistically analyzed using t-test to compare them with the rated equivalent ones recommended by their manufacturers and / or scientifically approved.

The analysis results indicated that the pumps were operating at efficiencies ranging between a minimum of 5 % and maximum of 59 %. These values were significantly lower than the approximated value of 50 % considered by Israelsen and Hansen (1962) as average centrifugal pump efficiency. Likewise, they were significantly lower than the rated values. In fact these low values of efficiency were statistically analyzed with the factors that affecting them using t-test and correlation coefficient to show if there is a significant effect for each one individually. As for pump adequacy, there was no significant difference between the actual discharge of these pumps per unit time per unit area and the water need required by the farms they irrigated whereas the potential (rated) capacities of these pumps were found to be significantly higher than the crop water requirements of these farms.

Regarding the overall efficiency, the results indicated that the studied pumping plants were operating with overall efficiencies ranging between minimum of 2 % and maximum of 48 %. In fact these values of overall efficiency were statistically analyzed with the factors that affecting them using t-test and correlation coefficient to see if there is a significant effect and / or difference for each one individually. Concerning the NPSHa, the results also revealed that the net positive suction head available by the studied pumping plants were ranging between a minimum of 1.02 m and maximum of 7.08 m. In fact these values of NPSHa were statistically analyzed with the factors that affecting them using t-test and correlation coefficient to see if there is a significant effect for each one. With regard to comparing the actual pump parameters to their equivalent rated ones, the results indicated that all the five actual parameters for the all seven types were found to be significantly lower than the equivalent rated ones except the pump speed parameter where there was no significant difference. As for comparing the pumping plants actual operating conditions with the rated equivalent ones, the results indicated that the values of power of the movers were significantly greater than the values of power required by the pumps they drive. In addition to that, the results also indicated that about 41.7 % of the studied plants have values of NPSHa significantly greater than the values of NPSHr and about 58.3 % have values with no significant

difference. Concerning the suction pipe sizing, the results showed that there was no significant difference between the actual values and the recommended equivalent value (pump intake nozzle size). With regard to the overall efficiency, the results indicate that about 66.67 % of the studied pumping plants were found to be operating with overall efficiency significantly lower than the rated theoretical equivalent values. Regarding the program application, the input data collected from the field was applied to the pumping plant evaluation program the results were found to be extremely close to those manually calculated. Concerning the program verification, the published relevant data of pump efficiency were inadequate. However, these limited data available by the previous similar studies were partially applied and treated by the program. The results reveal that there were significant differences in the model values of pump efficiency and the corresponding values reached by the former researchers. Such differences were justified. Moreover, the only available data concerning the calculation of overall efficiency was also inadequate but when the program input and output data applied to the formula used by the former researcher, the results were approximately closer to those obtained by the program. Regarding the NPSHa, there were no available data. The sensitivity tests revealed that the program could be used as an effective tool of predicting of the effect of the usually possible changes in the program inputs on the program main output parameters.

خلاصة الأطروحة

أجريت هذه الدراسة على المزارع الصغيرة الخاصة و التي تروى بمضخات طاردة مركزية بمحلية الحصاصيصا والمنتشرة على الضفة الغربية لنهر النيل الأزرق . لقد كان الهدف النهائي من هذه الدراسة هو تقييم أداء وحدات الضخ التابعة لهذه المزارع وذلك من حيث كفاءة المضخة، كفاية المضخة، الكفاءة الكلية للنظام وصافي ضاغط السحب الموجب الذي توفره هذه الوحدات ، إضافة إلى مقارنة ظروف التشغيل الفعلية للمضخات ولوحدات الضخ عموما بتلك الموصى بها من قبل المصممين و/ أو الموصى بها علميا بجانب تطوير برنامج حاسوبي لربط المحددات المدخلة بتلك المخرجة ومن ثم إنجاز عمليات الحساب المتعلقة بمثل عمليات التقييم هذه إضافة إلى تكوين صور شاملة عن الأداء تمكن المقيّم من التنبؤ بآثار التغيرات على ظروف الضخ. حيث كانت جميع هذه الوحدات مزودة بمضخات طاردة مركزية هندية الصنع وتدار أما بمحركات كهربائية أو مكائين تعمل بوقود الديزل كما أنها تقوم بسحب الماء إما من النهر أو من آبار سطحية وذلك لري مساحات تتراوح بين 2 فدان كحد أدنى و 40 فدان كحد أعلى . لقد تم إختيار 36 وحدة ضخ عشوائيا كعينة مسحية ممثلة لأفراد المجتمع الكلي والتي تقدر بحوالي 806 وحدة ضخ وذلك خلال الموسم الزراعي 2006-2007

أعتمدت الدراسة على بيانات أولية تم جمعها عبر استمارات الإستبيان والمشاهدة و / أو بالقياس المباشر. ثم أجريت العمليات الحسابية اللازمة للحصول على محددات التقييم النهائية المذكورة أنفا. وأخيرا تم تحليل هذه البيانات إحصائيا بإستخدام أسلوب التحليل الإحصائي المعروف بأسم برنامج الحزم الإحصائية للعلوم الإجتماعية (SPSS) ومن ثم تم شرح هذه النتائج وتبريرها وتفسير أثر العوامل المؤثرة عليها تم تصنيف المضخات الخاضعة للدراسة إلى سبعة أقسام وفقا لعلامة الصنع وهي) صراف 'كوما' 'لوساب' 'مارشال' 'أطلس' 'ألفا' 'أنيل' . ومن ثم تم قياس وحساب الخصائص التشغيلية الفعلية لكل نوع من هذه الأنواع حيث اشتملت هذه الخصائص (التدفق' الضاغط الديناميكي الكلي' السرعة الدورانية' عدد السيور على شكل حرف (v) و الكفاءة) ثم تم تحليل هذه القيم إحصائيا بإستخدام اختبار - ت لمقارنتها مع نظيراتها الموصى بها من قبل مصنعها و أخيرا فإن ظروف التشغيل الفعلية لوحدات الضخ هذه و التي تشمل (قدرة المحرك المستخدم ' صافي ضاغط السحب الموجب ' قطر أنبوب السحب ' و الكفاءة الكلية) . قد سجلت و/أو قيست و/أو حسبت ومن ثم تم تحليلها إحصائيا بإستخدام اختبار- ت بمقارنتها مع نظيراتها التصميمية أو الموصى بها علميا. أشارت نتائج التحليل إلى أن المضخات قيد الدراسة كانت تعمل بكفاءة تتراوح بين 5 % كحد أدنى و 59 % كحد أعلى. هذه القيم أقل بفرق معنوي من القيمة 50 % والتي نص عليها (Israelsen and Hansen 1962) كقيمة تقريبية للمتوسط المقبول لكفاءة المضخة الطاردة المركزية كما أنها أيضا أقل بفارق معنوي من القيم التصميمية الموصى بها من قبل المصنعين والمتوقع الحصول عليها من مثل هذه المضخات عندما تعمل في الظروف الموصى بها. وقد تم تحليل هذه القيم المتدنية للكفاءات إحصائيا وربطها مع العوامل المؤثرة فيها بإستخدام الأسلوب الإحصائي اختبار- ت ((t-test ومعامل الارتباط (Correlation Coefficient) لكل من هذه العوامل على حدة لمعرفة ما إذا كان لها أثر معنوي على كفاءة المضخة أم لا فيما يتعلق بكفاية المضخة فلم يوجد هنالك فرق معنوي بين التصرفات الفعلية لهذه المضخات لوحدة الزمن لوحدة المساحة وبين الاحتياجات المائية لهذه المزارع بينما هنالك فرق كبير بين السعات التصميمية لهذه المضخات و الاحتياجات المائية الفعلية لمحاصيل المزارع التي تروى بها هذه المضخات.

أما بالنسبة للكفاءة الكلية لوحدات الضخ هذه، فقد أبانت النتائج أنها كانت تعمل بكفاءة كلية تتراوح بين حد أدنى 2 % وحد أعلى 48 %. ولقد تم تحليل هذه القيم إحصائياً مع العوامل المؤثرة فيها باستخدام اختبار-ت ومعدل الارتباط لمعرفة ما إذا كان هنالك أثر أو فرق معنوي لأي منها على هذه القيم فيما يتعلق بقيم ضاغط السحب الصافي الموجب المتاح فإن النتائج أشارت إلى أن قيم صافي ضاغط السحب الإيجابي الناتج عن وحدات الضخ هذه قد تراوحت بين 1.02 متر كحد أدنى و 087 متر كحد أعلى. وقد تم تحليل هذه القيم إحصائياً مع العوامل المؤثرة عليها باستخدام اختبار-ت ((t-test) ومعدل الارتباط (Correlation Coefficient) لمعرفة ما إذا كان لأي من هذه العوامل أثر أو فرق معنوي على هذه القيم أم لا. أما فيما يتعلق بمقارنة محددات التشغيل الفعلية للمضخات بنظيراتها النظرية الموصى بها من قبل مصنعها فقد أشارت النتائج إلى أن هذه المحددات الخمسة بإستثناء السرعة الدورانية لكافة الأنواع السبعة قد وجدت أقل بفارق معنوي من تلك المقابلة لها و الموصى بها من قبل مصنعي تلك المضخات. بالنسبة لمقارنة ظروف التشغيل الفعلية لوحدات الضخ هذه بمثيلاتها الموصى بها علمياً فقد أشارت النتائج إلى أن قدرة المحركات المستخدمة أكبر بفرق معنوي من القدرة المطلوبة للمضخات التي تديرها. أما فيما يتعلق بضاغط السحب الموجب المتاح فقد دلت نتائج التحليل إلى أن حوالي 41.6 % من وحدات الضخ هذه لها قيم صافي ضاغط سحب موجب فعلية أكبر بفارق معنوي من القيم المناظرة لها الموصى بها والمتطلبة لكل مضخة، بينما في حوالي 58.3 % منها لا يوجد فرق معنوي بين قيمها الفعلية وتلك المتطلبة. بالنسبة لقطر أنبوب السحب فقد أشارت النتائج إلى أنه لا يوجد فرق معنوي بين قيم أقطار أنابيب السحب هذه وقيم أقطار مخرج السحب للمضخات الموصلة بها. فيما يتعلق بالكفاءة الكلية لهذه الوحدات وكما أشارت نتائج التحليل الإحصائي فإن حوالي 66.7 % من الوحدات تحت الدراسة كانت تعمل بكفاءة كلية أقل بفارق معنوي من القيم النظرية المفترضة والمقابلة لها. بالنسبة لبرنامج تقييم الأداء فإن البيانات الحقلية التي تم جمعها قد تم تطبيقها على البرنامج وقد كانت النتائج متقاربة للغاية مع تلك المماثلة لها والمحسوبة يدوياً. أما بالنسبة لاختبارات صحة البرنامج فإن البيانات المنشورة والمتاحة من الدراسات السابقة والمتعلقة بحساب كفاءة المضخة لم تكن كافية مقارنة مع متطلبات مدخلات البرنامج لذا فقد تم تطبيق هذه البيانات المحدودة جزئياً على البرنامج وقد جاءت النتائج بفرق معنوي كبير وقد تم تبرير هذا الفرق. أما ما يتعلق بحساب الكفاءة الكلية فإن البيانات الوحيدة المتوفرة من الدراسات السابقة كانت أيضاً غير كافية ولكن عندما تم تطبيق مدخلات البرنامج على المعادلات التي استعملت بواسطة تلك الدراسة كانت النتائج متقاربة لحد كبير للغاية. أما بالنسبة للبيانات المتعلقة بحساب قيم صافي ضاغط السحب الموجب المتاح فإنه لم تتوفر بيانات مماثلة من دراسات سابقة. أخيراً فإن اختبارات صحة البرنامج قد أوضحت أن البرنامج يمكن أن يستعمل كأداة فعالة للتنبؤ بأثر التغيرات الممكنة في قيم مدخلات البرنامج على قيم مخرجات المحددات الأساسية للبرنامج.