

بسم الله الرحمن الرحيم

: قال تعالى

قَالَ الَّذِي عِنْدَهُ عِلْمٌ مِّنَ الْكِتَابِ أَنَا آتِيكَ
بِهِ قَبْلَ أَنْ يَرْتَدَّ إِلَيْكَ طَرْفُكَ فَلَمَّا رَآهُ مُسْتَقِرًّا عِنْدَهُ قَالَ هَذَا
مِن فَضْلِ رَبِّي لِيَبْلُوَنِي ؕ أَشْكُرْ أَمْ أَكْفُرُ وَمَن شَكَرَ فَإِنَّمَا يَشْكُرُ
لِنَفْسِهِ ؕ وَمَن كَفَرَ فَإِنَّ رَبِّي غَنِيٌ كَرِيمٌ ﴿٤٠﴾

صدق الله العظيم
(سوره النمل آیه 40)

DEDICATION

Dedicated to:

My mother

My father

My wife

My family and my friends

My colleagues in Garri 4 Power Plant

With my love and respect

ACKNOWLEDGMENT

Thanks **God** in the first

Thanks to my supervisor

Prof. Sabir Mohammed Salih

For his assistance, guidance and endless help throughout the steps of this research work.

Thanks for any one helped me to make this work

Asim Abd Alla Salih

ABSTRACT

Garri4 Steam Power Plant works with regeneration Rankine cycle, It consists of two steam turbines each one generates 55 MW. In the Rankine cycle the steam jet air ejector or vacuum pump are utilized to generate and preserve vacuum in the condenser. Steam jet air ejector is simpler, lower cost, more reliable than vacuum pump , and does not consists of moving parts that need to be adjusted or repaired. Steam jet air ejector was installed in Garri4 but in commissioning operation ejector failed and did not satisfy the vacuum requirement for proper operation. To solve this problem two solutions were suggested and worked out, the first one is to replace the condensate water by fresh cooling water in the ejector's cooler, but also it still failed and the

second is to replace air ejector by vacuum pump which made vacuum sufficient to run the plant at full load.

In this thesis, the problem of the air ejector had been studied; also reasons of its failure, the effect of replacing air ejector by vacuum pump on plant efficiency, selection and the necessary modifications for the pump had been attained. The research method in this thesis is a theoretical survey case study. It was found that the main air ejector failure is due to design calculations errors of the ejector inner cooler, the pump was selected according to the capacity required of (1550. The pump type is two stage, liquid ring vacuum Pump. The replacing steam jet air ejector by vacuum pump allows the plant to run at full load (55MW), with high performance and a considerable efficiency of (25.46%) and a few required modifications. It is observed that the vacuum pump's running and maintenance cost are higher than ejector's that consumes (55 kWh) more than ejector's (36.86 kWh). The pump works permanently so, the power loss is (18.14 kWh) equivalent to (156.73 MW) per year; then the cost is about (109711 SDG) per year. From these calculations and considerations, it is obvious that recalculation, redesigning and installing of air ejector are convenient enough because of the lower costs. It is recommended to redesign and use the air ejector instead of vacuum pump utilization.

مستخلص

تعمل محطة قوى 4 البخارية لتوليد الكهرباء بواسطة دورة رانكن، وهى تتكون من وحدتين تنتج كل وحدة 55 ميغاواط. فى دورة رانكن يعمل قاذف الهواء بواسطة منفث البخار أو المضخة الخوائية على توليد الخواء والمحافظة عليه داخل المكثف. عند المقارنه بين قاذف الهواء بواسطة منفث البخار والمضخة الخوائية فإن قاذف الهواء بواسطة منفث البخار أقل تكلفة، أكثر فاعلية، أبسط ولا توجد به أجزاء متحركة تحتاج إلى صيانة أو إعادة ضبط. تم تركيب قاذف الهواء بواسطة منفث البخار فى محطة قوى 4، لكن فى التشغيل التجريبي فشل قاذف الهواء فى تلبية متطلبات الفراغ (الخواء) فى المكثف من أجل تشغيل أمثل للمحطة، تم تقديم وعمل إقتراحان لحل هذه المشكلة، الاول إستبدال المياه المكثفة بمياه التبريد لتبريد المبرد الداخلى لا قاذف لكنه أيضا فشل، والثانى إستبدال قاذف الهواء بالمضخة الخوائية مما صنع خواء كافيا لتشغيل المحطة بالطاقة القصوى.

فى هذا البحث تمت دراسة مشكلة قاذف الهواء ومحاولة معرفة الأسباب التى أدت لفشله، وتأثير إستبداله بالمضخة الخوائية على الكفاءة الكلية للمحطة، والتعديلات الضرورية لتركيب المضخة، وكذلك دراسة كيفية إختيار المضخة، وطريقة البحث فى هذه الاطروحة هى دراسة نظرية للحالة. وتم التوصل فى الدراسة الى أن سبب فشل قاذف الهواء بواسطة منفث البخار هو خطأ فى تصميم المبرد الداخلى لا قاذف وحساب الحمل التبريدى له، وأن إختيار المضخة تم وفقاً للسعة المطلوبة (1550 م³/س) ونوع المضخة هو حاوية السائل مرحلتين. وأن إستبدال قاذف الهواء بالمضخة الخوائية سمح للمحطة بالعمل بالطاقة القصوى (55 ميغاواط) وأداء عالى وكفاءة (24.46%) وتعديلات مطلوبة طفيفة. ولوحظ أن تكلفة صيانة وتشغيل المضخة أعلى من قاذف الهواء، حيث أن المضخة تستهلك (55 كواطس) وهو أعلى من إستهلاك قاذف الهواء (36.86 كواطس)، ونسبة لعمل المضخة المتواصل فإن نسبة الفاقد فى الكهرباء (18.14 كواطس) ما يعادل (156.73 ميغاواطس) فى السنة وهى تساوى (109711 جنيه) وهى كافية لتكلفة إجراء بحث وإعادة تصميم القاذف من جديد وتركيبه ولذلك تمت التوصية فى هذا الدراسة بإعادة تصميم واستخدام القاذف بدلاً من إستخدام المضخة الخوائية.

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List of symbols

symbols	Meaning	Unit
H	Specific enthalpy of steam	kJ/kg
	amount of work	kJ/kg
	amount of heat	kJ/kg
	saturation pressure	kg/m ²
	saturation temperature	K
	characteristic gas constant	kJ/kg K
Ws	amount of motive steam	kg/h
Wv	Amount of suction vapour	kg/h

Abbreviation

Efficiency

NEC	National Electricity Corporation Sudan
CMEC	China National Machinery and Equipment Import and Export Corporation
SJAE	Steam jet air ejector
CFM	Cubic Feet per Minute
PD	piston displacement
CFB	Circulating Fluidized Bed Boilers
LP	Low Pressure
HP	High pressure
CCW	circulation cooling water
I&C	Instrument and control system
MWh	Mega watt hour